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ABSTRACT

This unit is a part of a series of materials produced in a project to develop locally applicable class, lab, and field materials in ecology and social studies for Guam junior and senior high schools. While the materials were designed for Guam, many of the activities can be adapted to other localities. This unit covers ecological factors involving man, including sections on cycles, pollution, population growth, endangered species, technology, conservation of natural resources. Illustrations and examples provide specific information about the island habitat of Guam. (CS)

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Life On Guam
Human Impact

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by Margie Cushing Falanruw

art L Hotaling and Lita Payne

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Life On Guam

...a project to produce relevant class, lab, and field materials in ecology and social studies for Guam junior and senior high schools. Funding is through a grant under ESEA Titles III and IV, U. S. Office of Education——Department of HEW——whose policy, position, or endorsement is not necessarily reflected by the content herein.

> "....to ultimately graduate citizens who are knowledgeable and conscientious about environmental concerns of Guam and the rest of the World."

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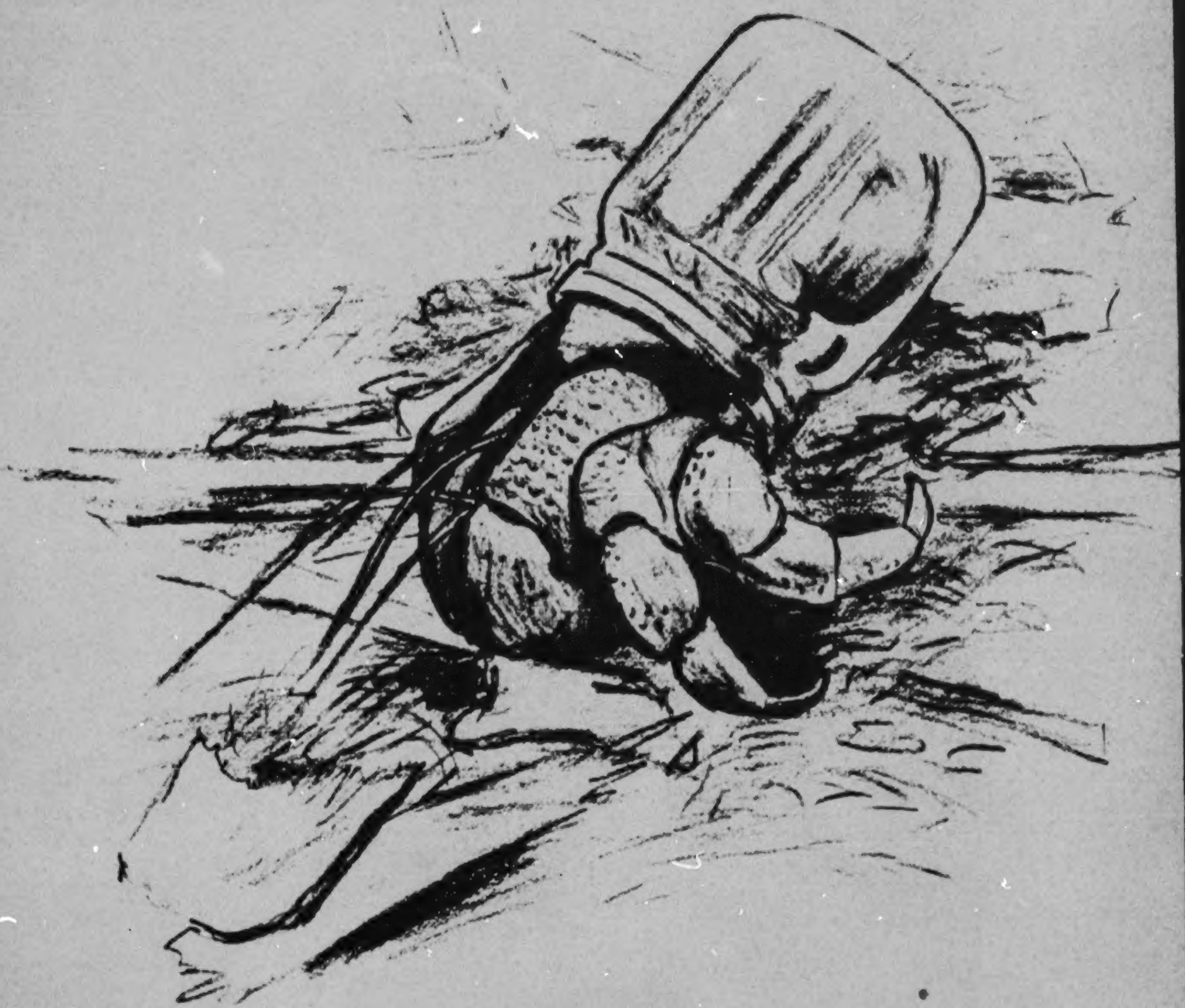


HUMAN IMPACT

1

Introduction

You're familiar with ecology. You know about pollution. This unit will deal with both of them. We'll think about the way people live and how they affect life on Guam and life on Earth.

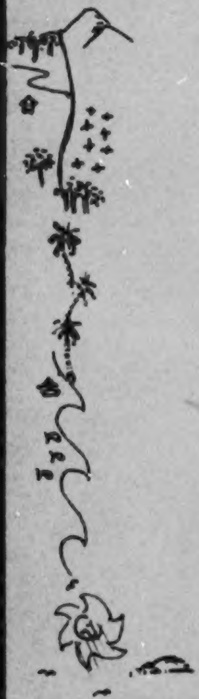
What To Do

1. Your Notebook——Write down what goes on during this unit. One thing emphasized here is that the Earth and its resources are limited. We don't have an unending supply of anything. To remind you of this, there will be no seconds on handouts. Conserve the first one you get.

2. Activities——There are a lot of them in this book to help you grab onto the subject. Your teacher will let you know which ones are required. You might do others for understanding or just for fun.

Take part in class discussions. Don't be shy. We all can learn a lot from each other.

Actions are even more important than words. Let your actions show your learning.



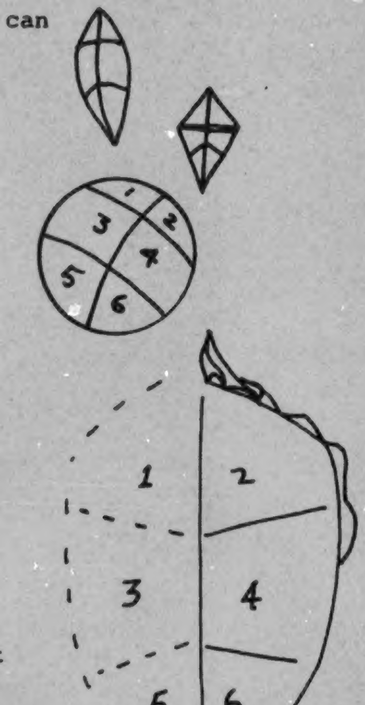
Activity 1 - Environmental Coat of Arms

In a framework like one of these or in one of your choosing, make an emblem to be placed on your notebook cover. For five of the blocks, make drawings. In the sixth, use either a drawing or words. Fill in the spaces like this:

1 & 2 - Sketch the two things in your environment you like the most.

3 - In the middle left block draw what you feel is the worst thing we are doing to our environment.

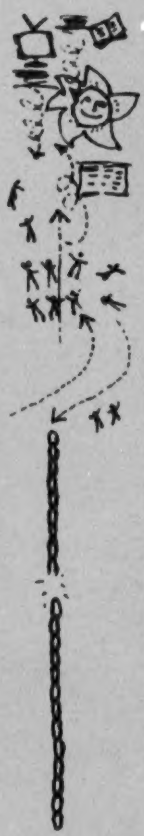
4 - In the middle right block sketch what you feel is the most significant thing you have done to improve the environment.



5 - In the bottom left block draw something you plan to do in the future that will benefit our environment.

6 - In the bottom right block draw or write anything you want to put in that concerns the environment.

Put your Coat of Arms on the cover of your notebook.



Activity 2 - Environmental Opinion Spectrum

Starting today, find statements in newspapers, magazines, or books, about the state of the World, resources, environment and pollution. Clip statements from newspapers, copy down those from magazines and books. (In all three cases, also write down the source.)

When you have collected a good batch of quotes set up an 'opinion spectrum' on a wall of the classroom. Show a range of opinions about the World environment. At one end put quotes saying the World will be in deep trouble in the future. At the other end, put the quotes saying the World is not in trouble. Between the extremes, arrange the rest of the quotations in order if you can. When you're finished you'll have an opinion spectrum. Throughout this unit, add to the spectrum.

Near the end of the unit, study the quotations and evaluate them. In your notebook, give your own opinions on the state of the World, considering three things: the quotes on the wall, what you have learned from this unit, and other facts.

Preview of Section I

This section describes some ways the natural World works. It deals with the things that keep us alive, like air, water and food. We'll look at how these things are produced and cycled and how the World is organized to share them.

If you're an ecologist already, just use this for review.

I—Some Basics of Ecology

To go ahead intelligently, it's good to have a background of collected knowledge about ecology. Ecology is the study of organisms and their physical and biological environment. The word comes from two Greek words, 'oikos', house, and 'logos', discourse, ≈ study of. Ecology begins with simple facts and concepts and goes on to involve everything in our lives.

Some Words

Organisms are individual living things, plants and animals. Species are different kinds of plants and animals. We give species two-part scientific names to distinguish one from another. You will notice these names because they're Latin, underlined or italicized, and the first letter is capitalized. We'll use some scientific names because common names aren't always well-known. Also, some species here don't have common names.

A population is a localized group of one species. Populations of different species living together are a community. We have natural communities like the plants and animals of the forest, or savanna, or reef, or mangrove mud flat. We have man-made ones like villages, farms, yards and roadsides.

A natural community with its non-living environment is an ecosystem. In an ecosystem, living and non-living things interact self-sufficiently. An ecosystem may be a puddle or a whole island. All together all the ecosystems of the World form the biosphere.

The Biosphere

It's a very thin layer around all the Earth. Therefore it's spherical and it's hollow. It's fragile. It has all the elements needed for life in solids, liquids and gases. It has water. It has life.

Most life on Earth is in a thin zone about 5 km thick. The upper limit of this zone is where water is in a liquid state. The lower limit is as far as light can penetrate into water.

The Age of It All

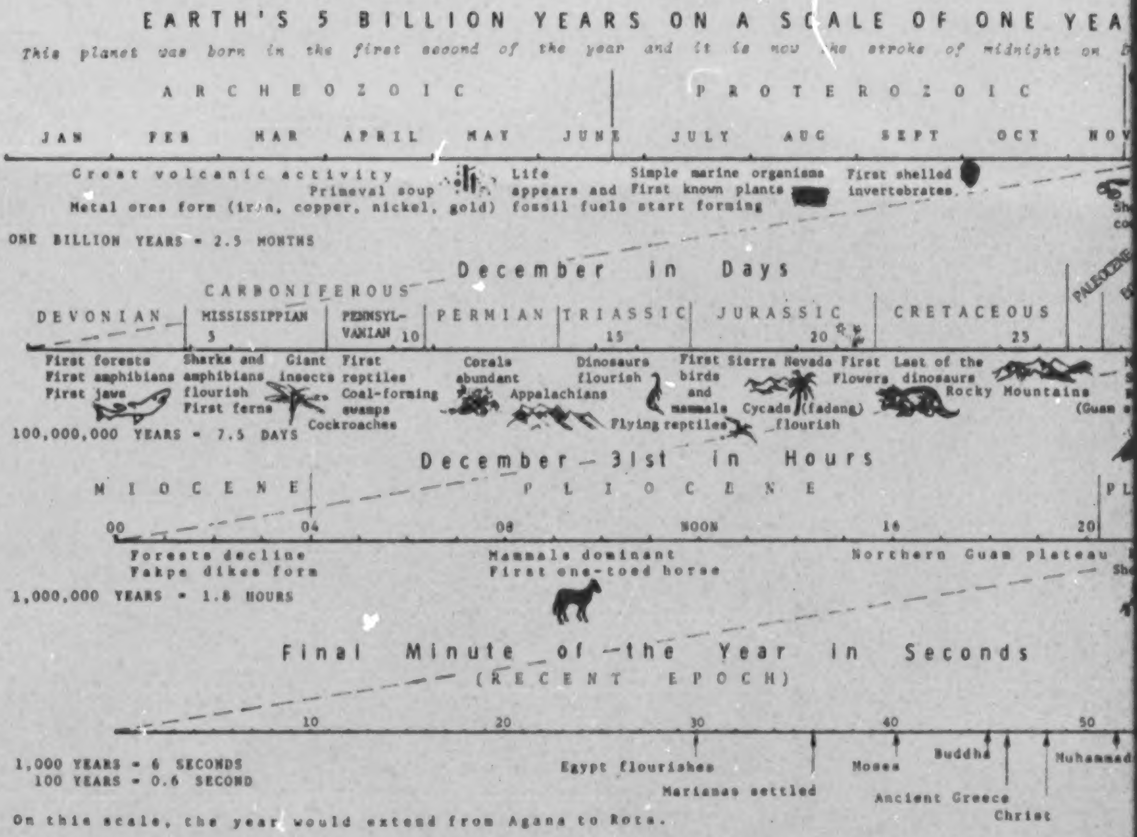
The Earth has existed for about 5 billion years. The first organisms appeared about 3 billion years ago. The first known plants came along about a billion years later. A billion years is pretty hard to think about. To make it easier, let's squeeze Earth's 5 billion years into one year. This is done in the Earth Time Chart on the next page.

We see here that most things we think about, like Guam, people, the modern World, even dinosaurs, happened very near the end of the year.

To get room to fit all these things in, we stretch out the month of December. Then we stretch the last day of December. Finally we stretch out the last minute of the year.

The reason to do the calendar this way is to picture how old Earth is and how young we are. We haven't been here long but we've sure changed things fast!

Earth Time Chart


EARTH'S 5 BILLION YEARS ON A SCALE OF ONE YEA
This planet was born in the first second of the year and it is now the stroke of midnight on D
ARCHEOZOIC
PROTEROZOIC
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
Great volcanic activity
Primeval soup
Metal ores form (iron, copper, nickel, gold)
Life appears and fossil fuels start forming
Simple marine organisms
First known plants
First shelled invertebrates
ONE BILLION YEARS = 2.5 MONTHS
December in Days
CARBONIFEROUS
DEVONIAN
MISSISSIPPIAN
PENNSYLVANIAN
PERMIAN
TRIASSIC
JURASSIC
CRETACEOUS
PALEOCENE
5
10
15
20
25
First forests
First amphibians
First jaws
Sharks and amphibians flourish
First ferns
Giant insects
Cockroaches
First reptiles
Coal-forming swamps
Corals abundant
Appalachians
Dinosaurs flourish
Flying reptiles
First birds and mammals
Sierra Nevada
Cycads (fadang) flourish
First Flowers
Last of the dinosaurs
Rocky Mountains
(Guam
100,000,000 YEARS = 7.5 DAYS
December 31st in Hours
MIOCENE
PLIOCENE
PL
00
04
08
NOON
16
20
Forests decline
Fakpe dikes form
Mammals dominant
First one-toed horse
Northern Guam plateau
1,000,000 YEARS = 1.8 HOURS
Final Minute of the Year in Seconds
(RECENT EPOCH)
10
20
30
40
50
Egypt flourishes
Marianas settled
Moses
Buddha
Ancient Greece
Christ
Muhammad
1,000 YEARS = 6 SECONDS
100 YEARS = 0.6 SECOND
On this scale, the year would extend from Agana to Rota.

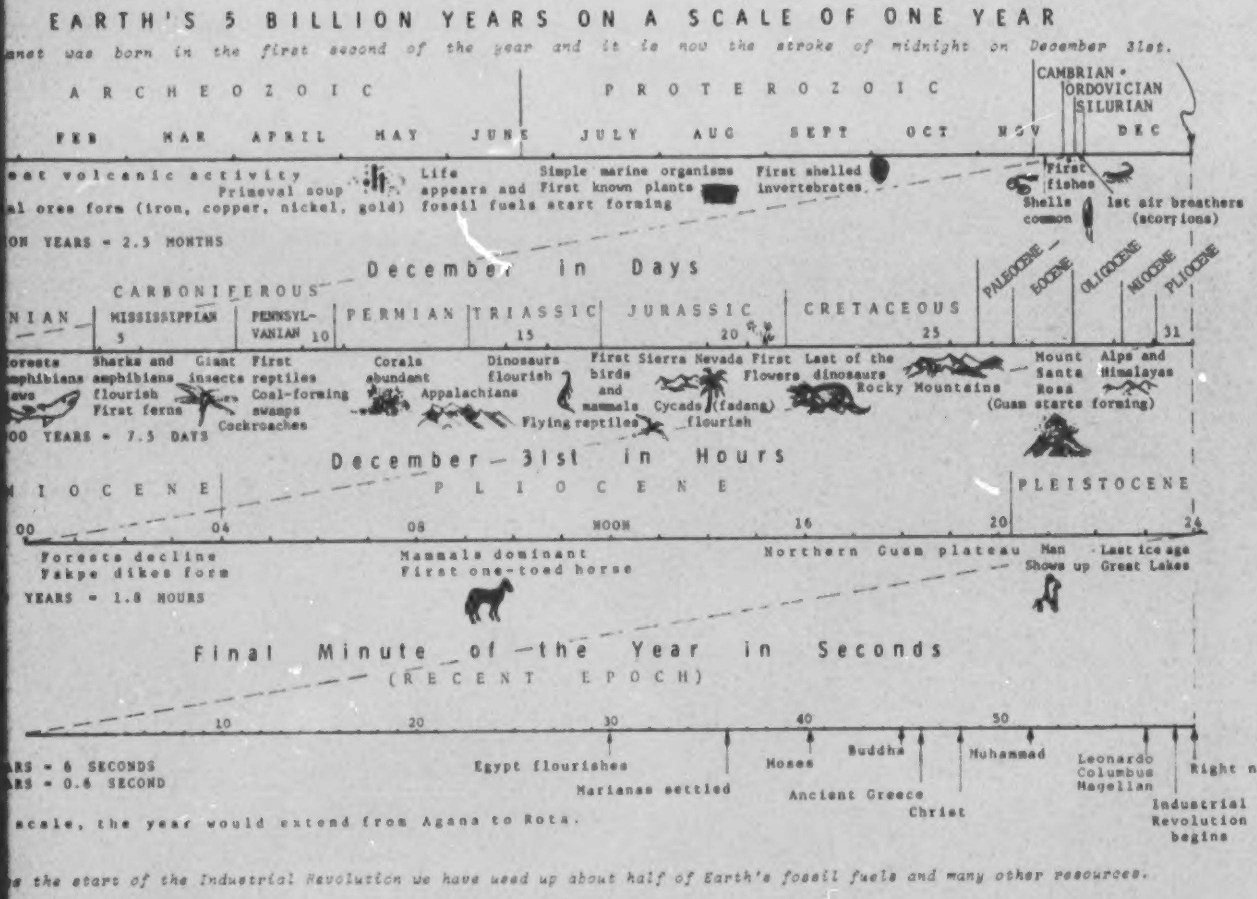
Since the start of the Industrial Revolution we have used up about half of Earth's fossil fuels and many other

Activity 3 - The Age of Earth and Man - When did li

Christ arrive? When did fossil fuels

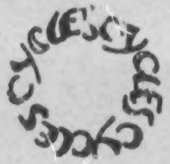
How long has it taken Man to use up ha

Earth Time Chart



Activity 3 - The Age of Earth and Man - When did life, Man, and Christ arrive? When did fossil fuels start forming? How long has it taken Man to use up half of them?

Earth is a grand mother. Today she provides for about 2 million species. Besides these, there were maybe as many more species in ages past. How is it possible that the limited amount of elements in the biosphere can support so much life? The answer: 'By recycling!' We don't consume the life-giving elements, we only borrow them. They pass through us giving us life and being. Then they continue on to support the rest of life on Earth. The air you breathe was here to be breathed by George Washington, Socrates, cavemen, dinosaurs, and tiny algae! Will it be here 2 billion years from now?

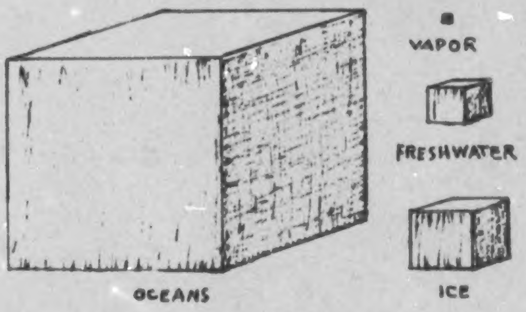


There are many complex natural cycles. We'll look at simplified versions of a few to get some idea of the great processes going on to give life to Guam and to Earth.

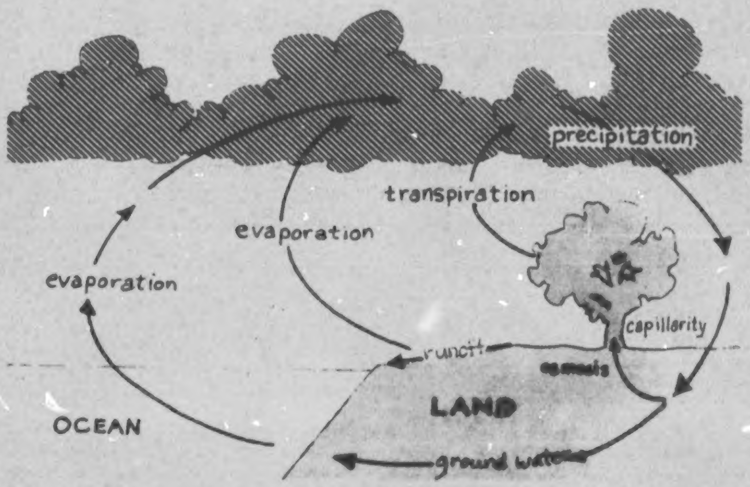
Water

Water is the medium of life processes. They happen in it. Life began in water. All life needs water.

Distribution of the World's water is shown here. (After *Scientific American*)



Only a small amount of water is present at any one time as vapor in the atmosphere. This vapor plays a big part in the weather. It is the most dynamic, fast-changing stage in the great water cycle. Any water not locked up in glacial ice moves continuously through the cycle.



This water cycle diagram shows surface water evaporating to become water vapor in the atmosphere. Eventually this vapor gathers in clouds and condenses back into liquid or solid water. It falls to Earth as rain, snow or some other kind of precipitation. Snow melts and water gathers into puddles and streams and ponds and lakes and runs into the ocean. Eventually it evaporates again and the cycle continues.

6

A nice thing about the water cycle is that it is also a cleaning cycle. When water evaporates, most of its impurities stay on the ground. That happens when a muddy puddle evaporates; it leaves its dirt behind and becomes clear rain.

The biological part of the water cycle is essential to life. Most of the water which supports life passes through plants in a great invisible stream. Soil water (from rain) is absorbed into root cells of a plant by osmosis. In osmosis water moves from a place where it's more abundant to one where it's scarcer: in this case from the soil to plant root cells. From here water moves through tiny tubes by capillary action——it crawls up the tube walls, pulling lower-down water after it. When it arrives at the leaves, water transpires through thousands of tiny pores on leaf surfaces into the atmosphere. (For some reason, when a plant gives off water the process is called transpiration. When horses, you and I do it, it's something else.) Transpiring water in the leaves pulls more water upward; this is transpiration pull. Wind, heat, and dry weather speed up the activity.

It's been estimated that for a plant to make 1 kg of itself 200-1000 kg of water must be taken in by its roots. Most of this water passes right through the plant. In doing this, water makes cells turgid——full and firm. This gives the plant its shape and support. Water also carries nutrients (food) throughout the plant.

Water keeps animals alive also. Human beings, for example, can go without food for a few weeks, but dehydration and death occur after a few days without water. About 75% of a person is water. How much do you weigh? How much water are you carrying around?

In a hot place like Guam a person takes in about 3.4 liters of water a day. Two-thirds of it comes from drinking, one-third from our food. Each day we lose about the same amount of water as we take in. Body fluids——mostly water——are pumped around by the heart. They carry food and oxygen to and remove carbon dioxide and waste products from the cells. Water is necessary for our temperature regulation. The water balance of our bodies determines the efficiency of circulating, cleaning, and regulating body fluids.

Many organisms, including animals like us and land plants, depend on freshwater. But only about 0.65% of the Earth's water supply is available as freshwater. That's less than one percent! Consider the great importance of protecting the supply of freshwater!

Fish need freshwater, too. Most marine fish get their supply by constantly drinking sea water. Then they remove the excess salts with special organs. Marine algae and the simpler invertebrates (animals without backbones, mostly small) have a great percentage of their body cells in continual contact with sea water. Food and waste products may be exchanged immediately with the water, and fancy pumping systems aren't necessary. Consider the effect of water pollution on these vulnerable creatures. Most of their cells are exposed directly to any pollutant in their watery world.

Some Chemistry——The Carbon and Oxygen Cycles

Living matter is mostly carbon, hydrogen and oxygen. Oxygen is the most immediately needed. Most plants and animals use oxygen in the cells in a kind of 'slow burning' that releases energy from foods. This energy is used in life processes.

Carbon is part of all living things. It circulates through living matter and becomes fixed into food and living tissue. Some of it gets stored in rocks, coal, and oil.

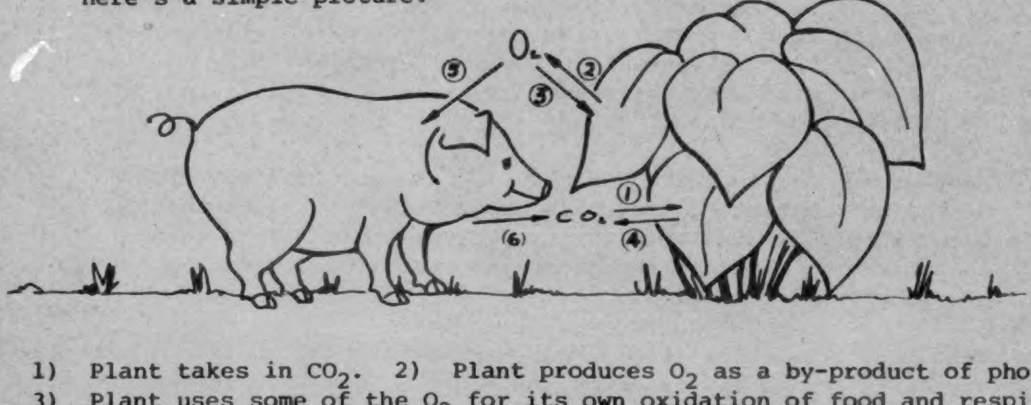
The carbon, carbon dioxide, and oxygen cycles are linked together. The key in this linkage is photosynthesis. In this process green plants capture the Sun's energy. Chlorophyll is needed too, to combine carbon dioxide and water into food, with oxygen as a by-product. In chemical shorthand it looks like this:

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$$

Food and oxygen combine to produce energy and carbon dioxide. In chemical abbreviation again:

$$C_6H_{12}O_6 + O_2 \longrightarrow \text{energy} + CO_2$$

Here's a simple picture:

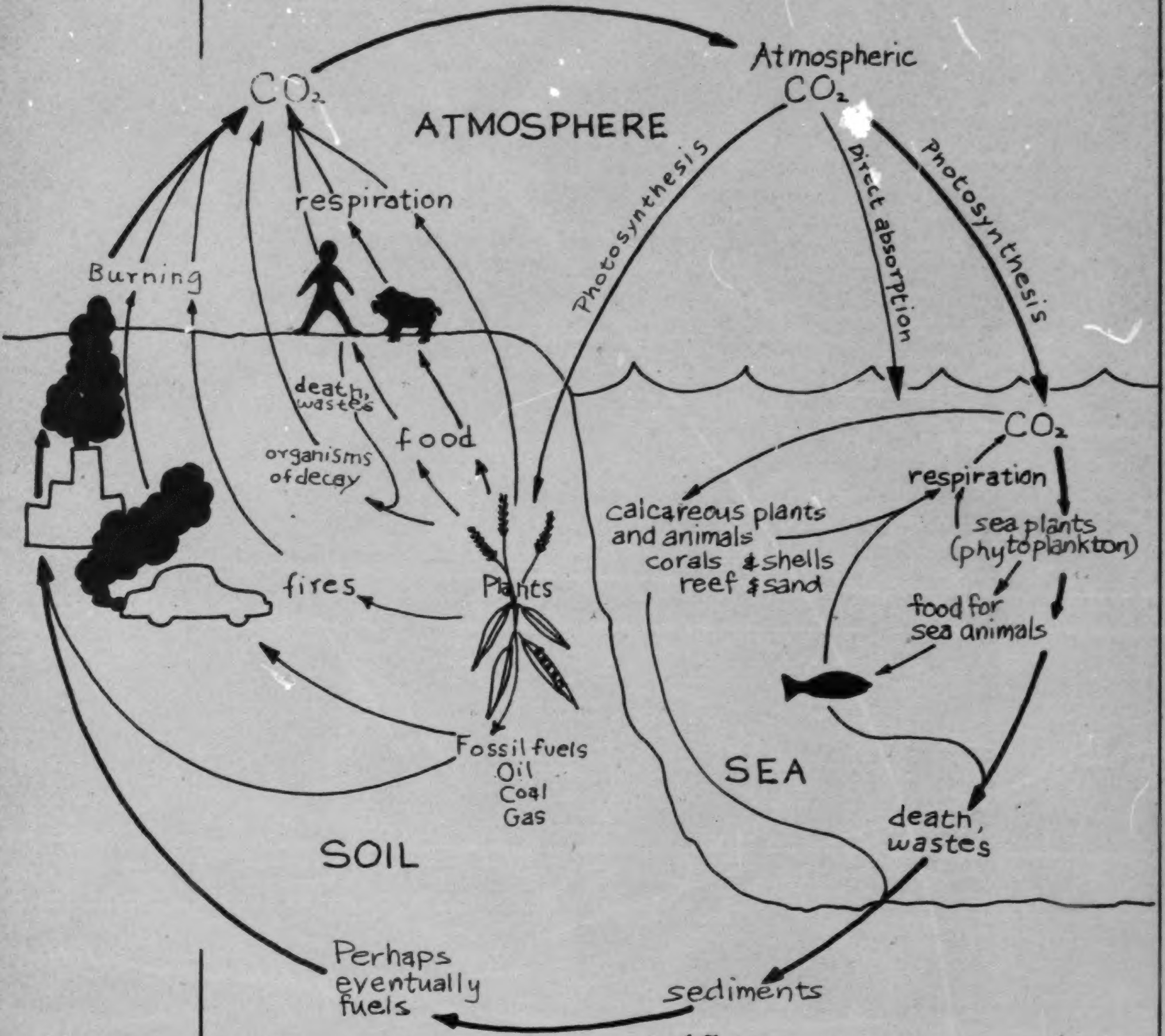


1) Plant takes in CO_2. 2) Plant produces O_2 as a by-product of photosynthesis. 3) Plant uses some of the O_2 for its own oxidation of food and respiration and 4) gives off CO_2. 5) Animal uses O_2 and 6) gives off CO_2.

Carbon-Oxygen Exchange -- -

8

Other types of burning besides the slow oxidation of food in body cells produce carbon dioxide. Today machines put a lot more carbon dioxide into the air than ever before. Atmospheric carbon dioxide dissolves in ocean water and some carbon ends up in sediments and in the skeletons or shells of marine organisms. The entry of carbon into calcareous (= with calcium) marine plants and animals is of special significance. It is this process which gave us most of our coralline Island of Guam. Here's a detailed diagram of the carbon cycle.



ATMOSPHERE
CO_2
Atmospheric CO_2
respiration
Burning
Photosynthesis
Direct absorption
Photosynthesis
death, wastes
food
organisms of decay
fires
Plants
Fossil fuels
Oil
Coal
Gas
SOIL
CO_2
respiration
calcareous plants and animals
corals & shells
reef & sand
sea plants (phytoplankton)
food for sea animals
SEA
death, wastes
sediments
Perhaps eventually fuels

Carbon Cycle

The Nitrogen Cycle

Nitrogen is in amino acids, the building blocks of proteins. Although 79% of the atmosphere is nitrogen, it cannot be used by most plants unless it is part of a chemical compound called a nitrate. Certain bacteria and algae 'fix' nitrogen from the atmosphere into nitrate compounds. These bacteria often live in nodules, bumps on the roots of some plants. Such bacteria-harboring plants are important in keeping the soil productive.

Many people here say that where tangantangan grows there is good soil. Tangantangan is in the bean plant family, and like many beans has nitrogen-fixing bacteria in its roots. Plants that have nitrogen-fixing bacteria may be able to colonize areas that have nitrate-poor soil. They just bring their own nitrate-makers with them! Such plants can be pioneers and start up a whole community in a formerly bare area.

You probably know *Nostoc*. It's that slippery, squishy, dark blue-green alga on lawns and alongside old roads and airstrips, especially after rain. *Nostoc* fixes nitrogen. That's why it can live where there is very little soil. Often on a bare place you can find a patch of pure *Nostoc*. A little further to the side, moss grows on it. Then further along, other little plants grow on the humus left from the *Nostoc* and moss. Finally soil is developed and bigger plants can grow.

Today nitrates are used in fertilizer and more are being added to the ground and water than ever before. In the future we may have problems of too much nitrate in the environment. (See *Schoolyard Ecology* in this LOG series, pp. 24-26.)

The Energy Cycle

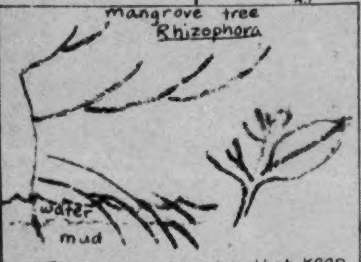
Life is maintained by photosynthesis, which captures a small amount of the Sun's vast energy. Green plants use the Sun's energy to make simple sugars. These can be built up into many complex organic compounds. Organic compounds contain carbon. Carbon is in food, shelter, clothing, paper, pencils, boats and lots of other things. We can't live without green plants, which also provide oxygen. They can't live without the Sun.

Most sunlight coming to Earth is reflected back into space. Most of the energy that does reach Earth goes to produce our weather. Only about one-tenth of one percent of energy received from the Sun by Earth is fixed by green plants. (That's 0.1 of 1% = 0.1 x 0.01 = 0.001%.) About half of this captured energy is used up internally by plants. Our lives and the lives of other animals are dependent on the other half of 0.001% of the Sun's energy captured by plants. The total amount of life that can exist on Earth is determined by the amount of this energy.

Here is one natural cycle which is not complete. The Sun's energy comes to the biosphere. It's trapped by green plants, and kept for a while to flow through the food chain. Eventually this energy radiates back into space as heat. It does not return to the Sun but someday, a very long time from now, the Sun will run down and this cycle will cease. So will all the others.

Activity 4 - How Plants Capture the Sun

There are many many kinds of plants with many different growth habits, shapes and sizes of leaves. One of the main problems of a plant is to get the right amount of sunshine. Where there is plenty of rain and soil is good, plants compete for sunlight. Some produce big leaves. Some grow tall. Some spread out on top. Some have leaves that follow the Sun. Some have many small leaves. Some have no leaves but produce food with the chlorophyll in their stems. All these different methods of catching the Sun have advantages. For example, big leaves catch a lot of Sun; however, they shade the leaves under them on the same plant. If a plant grows tall it can catch a lot of sunlight for itself. It takes a lot of energy to grow taller than the other trees around. A tall tree can shade out competitors and thus beat them in the competition for sunlight, but when it drops its own seeds, the seedlings may not grow well because they are shaded out by their parents. Vines take advantage of trees and climb up on them to reach the sunlight.

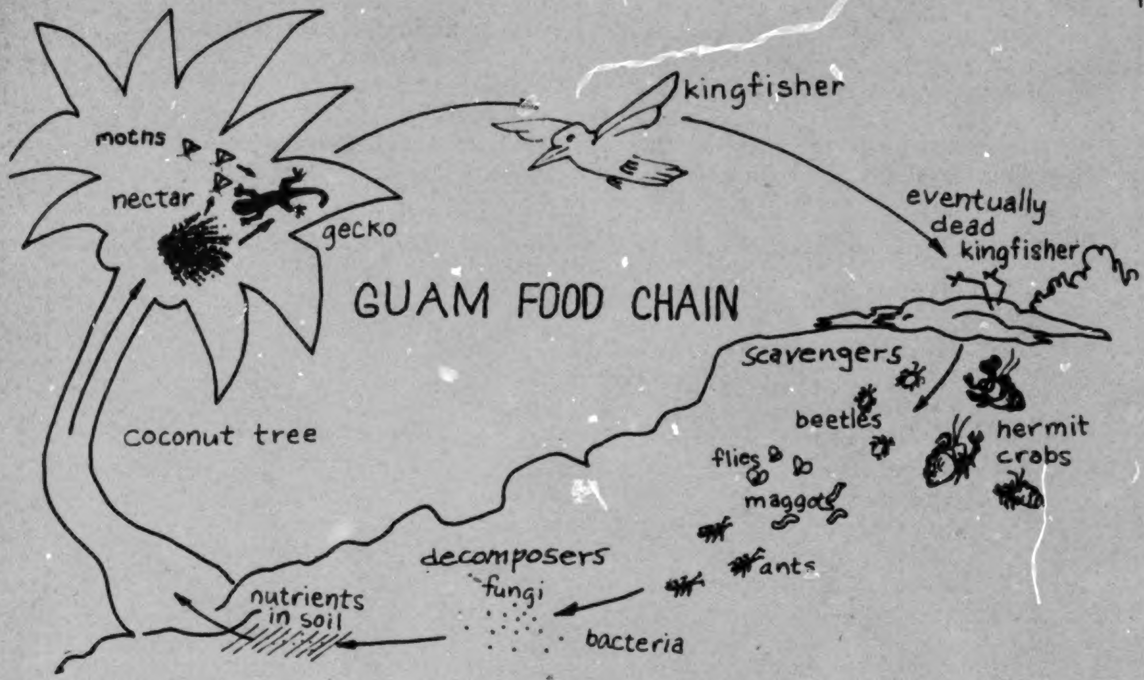


This tree has branches that keep looping out away from the center of the tree. By spreadingout like this they can get more sunlight. They don't fall over because of the prop roots. The leaves are held at different angles so that they can catch the sun from many angles and also so they won't shade each other.

Look at the different kinds of plants around you. Study the growth plan and leaves of each. Pretend that these plants can think and that each one has a plan to get more sunshine than its neighbors. Choose three plants and outline their shape and leaves. Explain what you think their plan is to get lots of sunshine for themselves. Put each outline and explanation on a separate sheet of paper. Compare outlines. Make some conclusions about them.

The Food Chain

Solar energy flows in food chains and webs. Here's a food chain:

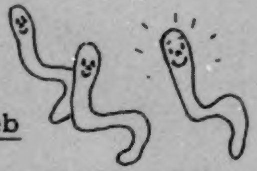

kingfisher
moths
nectar
gecko
GUAM FOOD CHAIN
eventually dead kingfisher
scavengers
beetles
hermit crabs
flies
maggots
ants
coconut tree
decomposers
fungi
bacteria
nutrients in soil

A coconut tree makes food. It is the producer. An animal, a moth, eats nectar from coconut blossoms. It is a herbivore, a plant eater. It's a primary consumer because it is the first animal to use the energy captured by the plant. A gecko eats the moth, an animal. If it eats only animals it is a carnivore, a meat eater, a secondary consumer. Some geckoes eat both insects and plant nectar. They are omnivores (= 'all-eaters'). Sihik, the kingfisher, eats geckoes. Sihik is a carnivore and secondary consumer. Sooner or later the plants and animals die. Their bodies are broken down by scavengers like those shown, and by decomposers including fungi and bacteria. These small organisms break down the dead material into soil nutrients to be used again by growing plants. Thus the cycle keeps turning.

A Word About Scavengers and Decomposers

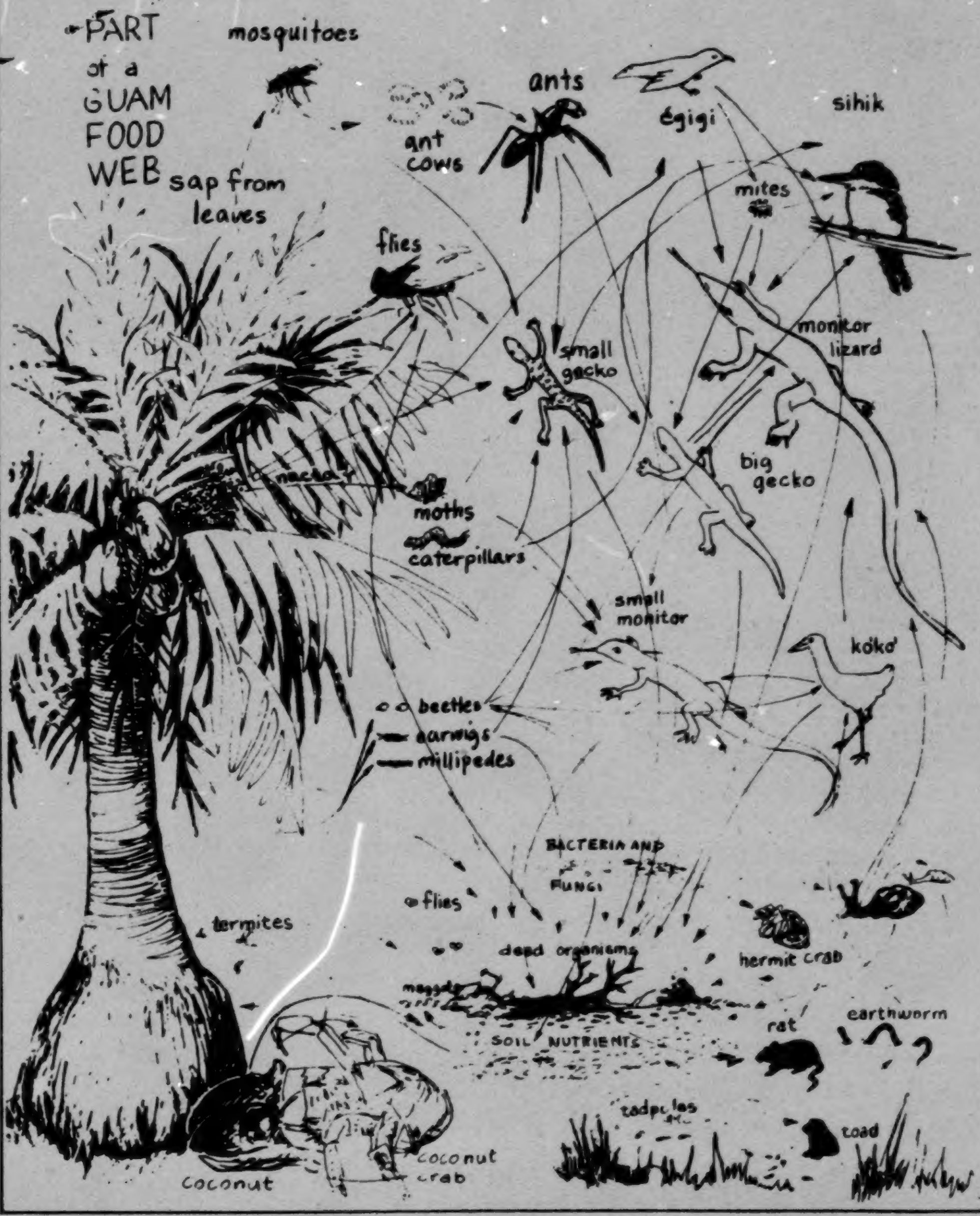
Some people react to organisms like worms, crabs, ants, beetles, fungus and bacteria with 'Ugh, kill 'em'. Some worms, insects, fungus and bacteria may have harmful effects, but these are only a very few out of many many organisms. To say that all of them are bad is like saying 'All dogs are mean'; you know that's not so.

If we didn't have scavengers, and especially decomposers, there would be dead bodies piled all over the place! The cycle of nutrients through the food chain back into the soil and atmosphere would stop.



Next time you see a worm, how about a 'Thank you!'

Food Web Food chains as simple as the one on page 11 seldom occur in Nature. There's generally a lot more going on. The following diagram shows a more detailed picture of energy transfer, but it too is less complex than the arrangements in natural communities.


PART of a GUAM FOOD WEB
mosquitoes
sap from leaves
ant cows
ants
égigi
sihik
mites
flies
monitor lizard
small gecko
nectar
moths
caterpillars
big gecko
small monitor
kòkò
beetles
earwigs
millipedes
BACTERIA AND FUNGI
flies
termites
dead organisms
hermit crab
maggots
SOIL NUTRIENTS
rat
earthworm
tadpoles
toad
coconut
coconut crab

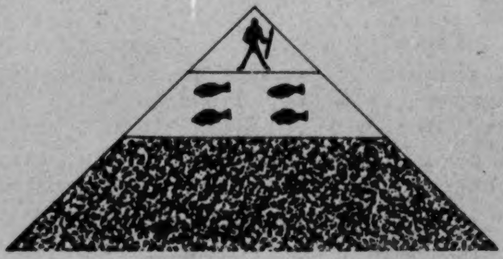
Complexity

The more complex a community is, the more stable it may be. Simple ecosystems and communities are likely to have big population changes from time to time. For example, look at the food chain on page 11. What happens if the moth population increases during several years when weather conditions are good? Do gecko and sihik populations increase also? Then, suppose there is a long dry season and the moths die off. What would happen to the gecko and sihik populations? Now suppose we have a situation like the food web on page 12. What would happen here if the moth population died out? Would the basic structure of the community change very much?

On our Island two different factors affect the complexity of natural communities. The weather is usually great for life on Guam. There's generally enough moisture and it's warm so plants and animals can easily live here. On the other hand, this is a small and isolated island. It's hard for great varieties of organisms to get here in the first place. Guam's relatively small size doesn't favor the expansion of some species.

Natural ecosystems tend to be complicated while man-made ecosystems tend to be simplified. A forest, for example, is a lot more complex than a ricefield. The forest supports many kinds of organisms, the rice field only a few. Name some. A rice-eating insect getting into a rice field would have a great time. Its population could grow until it wiped out all the rice. In a forest an insect might kill a few of its favorite trees but probably not all, especially if they were scattered around in the forest. Even if the insect did kill all the trees of one species, the forest could go on with others. The forest community is complex and stable.

Ecological Pyramids and Bioamplification



As we go along a food chain, we find that the biomass (weight) of the food is always greater than the weight of the eater.

If you weighed all the food you have eaten, it would weigh a lot more than you. Why? Because food is used not only to make you grow but also to give you energy. Food used for energy doesn't add to your weight, you 'burn' it up.

The relationship is shown in the pyramid above. This is a simple food chain: seaweed (algae) eaten by sesyon (rabbitfish), eaten by man. The diagram demonstrates that it takes a lot of algae to feed a few sesyon to feed one man. To generalize, it takes a lot of producers to feed a few herbivores to feed one carnivore. This tells us that it takes a lot of lagoons full of algae to support fish-eating people. It would take even more lagoon area to support barracuda-eating people. (Alu, the barracuda, is a carnivore, a secondary consumer.) The farther along in a food chain an organism is, the more producers and space it takes to support him. As the human population grows we will become more and more aware of this.

On Guam we eat a lot of meat. We act a lot like secondary consumers. We eat as though we have a lot of land and sea to support us. As the human population grows, we may have to abide by the rules of the pyramid of biomass and move down the food chain, perhaps until we are mainly primary consumers. A hectare of land can support a lot more people eating rice and soybeans than people eating pigs eating rice and soybeans!

Bioamplification

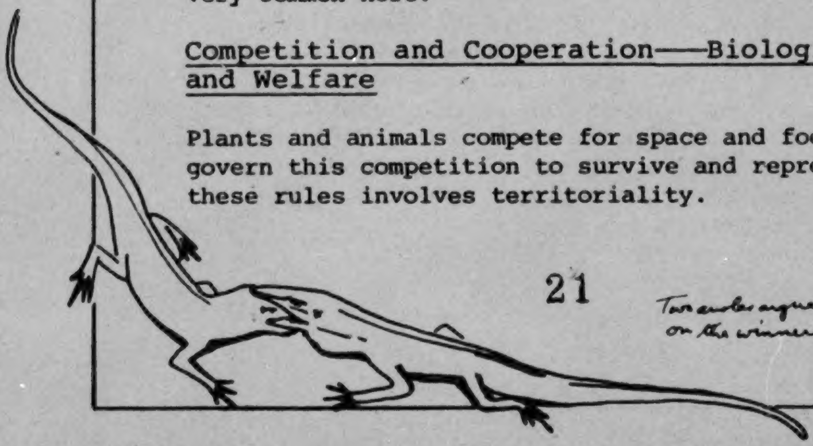
The pyramid of biomass also helps us understand how some things get concentrated in natural systems. Suppose a certain type of plant has a weak poison in it, or sprayed on it. Say there's only 0.001 gram of poison per plant. Now a chicken comes along and eats 100 of these plants during its lifetime. The chicken gets 0.001 x 100 or 0.1 g of poison. Suppose the poison doesn't kill the chicken but collects in its meat. A person eating 100 of these chickens in a lifetime could get 0.1 x 100 g of poison.

0.001 g poison per plant	x	100 plants eaten by each chicken	x	100 chickens per person	=	10 g poison in one sick or dead person

Ciguatera is a kind of poisoning which may result from bioamplification. Perhaps you know people who won't eat big red snappers or barracuda or eels, which are carnivorous fish. They eat a lot of herbivorous fish. Each herbivore might pick up a little poison from some plant or other. Ciguatera is a serious recurrent problem in many parts of the Pacific. The source of the poison hasn't yet been discovered. Fortunately, it is not very common here.

Competition and Cooperation——Biological Warfare and Welfare

Plants and animals compete for space and food. Natural rules govern this competition to survive and reproduce. One of these rules involves territoriality.



Two anoles argue over land; a spot on the winner's cheek turns dark.

Territoriality

Plants and animals require living space. The amount varies with species and conditions. Look at birds on a power line; they're generally pretty evenly spaced. Tied-up dogs are often very defensive of their limited area. Dogs in their master's yard know the limits of their territory whether or not it is fenced in. Have you ever seen a big dog chase a little dog and suddenly the little dog turn and start chasing the big dog? It's because the little guy's reached his territory and knows he has the right to defend it even against the bigger dog. Snorkel around coral heads and look for fomho', Pomacentrids, damselfish. Many of them defend a home territory and may even try to drive you away with their brave little lunges!

Territoriality does a lot for natural communities. It assures that populations don't get too big. When territories become too crowded or changed, natural populations adjust until they reach a number that existing conditions can support.

Natural Selection

The success of any species depends on whether it can produce strong young to continue the species. Natural selection weeds out the unfit, leaving the fit to reproduce. By this principle, strong individuals are more likely to succeed than weak ones. Species well-adapted to their environment are a lot more likely to make it than species that don't fit theirs.

Natural selection works wonders. It's not just strength that makes a species successful, or else the World would be full of big strong ferocious creatures only. Some species assure their success by being really good at reproducing. The roundworms in our intestines don't do much else but eat and produce eggs in the thousands and thousands. That may not be a very exciting life, but it assures continuation of the species. Elephants, whales and porpoises have only one young at a time but take very good care of it. Some species increase their chances of success by being attractive. Colorful, sweet-smelling flowers attract bees which pollinate them. The flowers thus produce seeds for the next generation of plants. Many male birds are very colorful. This attracts females. Some animals behave in elaborate ways. Perhaps you've seen *Anolis*, the American chameleon, a new lizard on Guam that's usually green but can change to brown. It puffs up its red neck flap to warn other males to stay out of its territory and to invite females in.

Some species are successful because of their social organization. Bees have a complex society. Some are specialized at collecting nectar, others guarding the hive, others to act as living storage bags, others to nurse the young, and a queen bee who does nothing but mate once and lay eggs for the rest of her life. Some species are successful by being helpful to others. For example, one pretty little fish, the cleaner wrasse, hangs around a certain place on the reef. It does a sort of dance to attract fish to come by and have their parasites picked off. The wrasse gets a meal (sometimes right out of the mouth of a larger fish!), and the big fish gets rid of its parasites.

Natural selection has resulted in a vast array of interesting and beautiful life forms. We can understand reasons for some adaptations. Others leave us wondering.

Productivity and Carrying Capacity

Ecologists who study productivity measure the amount of oxygen yielded as a by-product of photosynthesis. Or they measure the weight of carbon or other element fixed. What they're after is to try to determine how much of the Sun's energy was captured. This is difficult to do for one organism alone and even more difficult for a community of organisms, but ecologists are working away at it.

Land farmers and aquaculturists (water farmers) also talk about productivity. What they refer to is the amount of food for man that is raised in a particular area of land or water. Economists are interested in how much money is spent in raising this food compared to the money earned from selling it. Measuring productivity in terms of food or cash products is much easier than measuring total biological productivity.

Carrying capacity is the amount of life that can be supported in an ecosystem. Ecologists are interested in the numbers and biomass of all the different organisms making up the natural community of an ecosystem.

Agriculturists and aquaculturists are interested in an area's ability to support certain organisms. They would like to know how many eels you can raise in a hectare pond, or how many cows on a hectare of land.

Ecologists and planners are in interested in how many people this Earth can support.

An Ecological Ideal

We'd like to have a biosphere with all its natural cycles revolving smoothly and continuously, with the highest level of productivity and the greatest biological complexity possible. This environment would be stable, healthy and a very interesting place to live.

How we might achieve this ideal environment is a problem. To live in it we would have to abide by certain ecological rules:

1. Don't interfere with natural cycles.
2. Don't push any species to extinction (don't kill them off).
3. Don't consume nonrenewable resources.
4. If you want to be a top carnivore, don't allow your population to exceed the environment's carrying capacity for top carnivores.
5. Don't overpopulate the Earth.

With modern techniques we have been able to produce lots of food for man. We have used fossil fuels (petroleum products for tractors, etc.), pesticides and artificial fertilizers which may interfere with natural cycles, and monoculture, which lowers complexity. To support so many meat-eating people, we have had to do away with many competitors for food and space. Clearly we aren't headed towards the environmental ideal.

We've broken a lot of ecological rules. So far the result is a World where many people are starving and many species are threatened with extinction. Some people are very concerned about this state of affairs. Others don't know it exists.

Some Rules of Thumb

Ecology involves a lot of very complex information and theories. Here are four simple ecological rules of thumb:

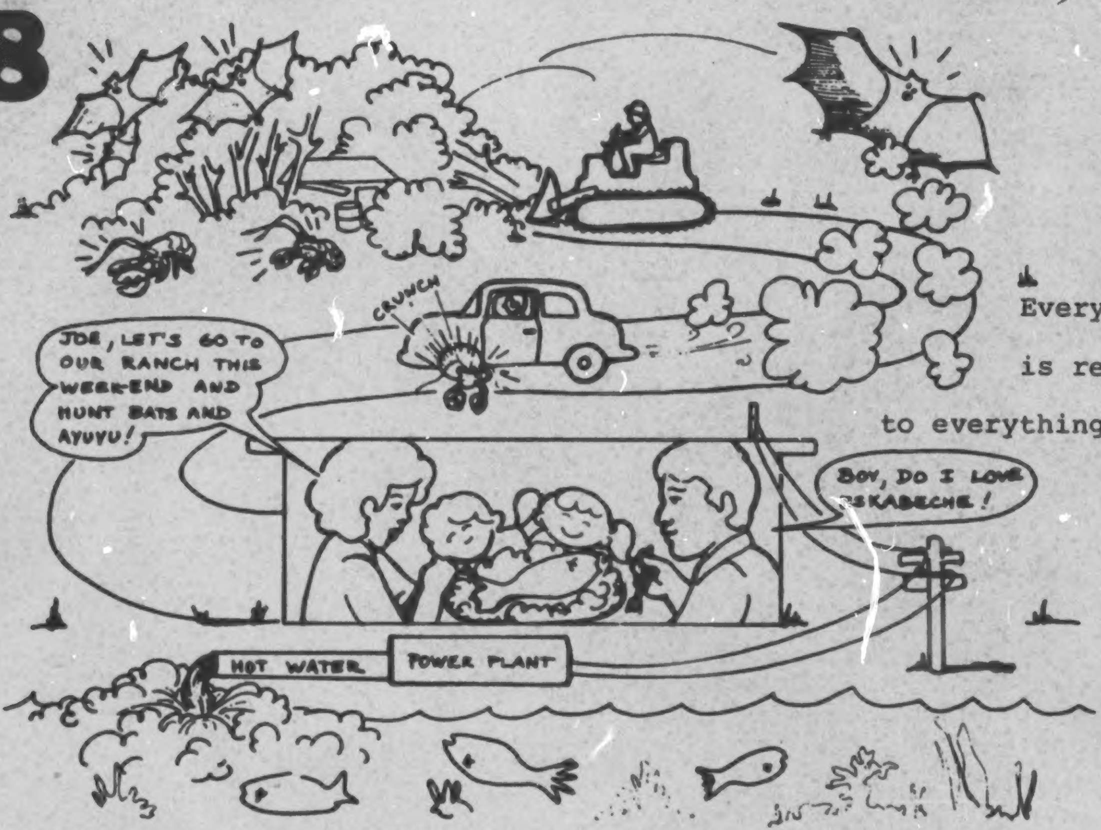
Everything is related to everything else.

There's no such thing as a free lunch.

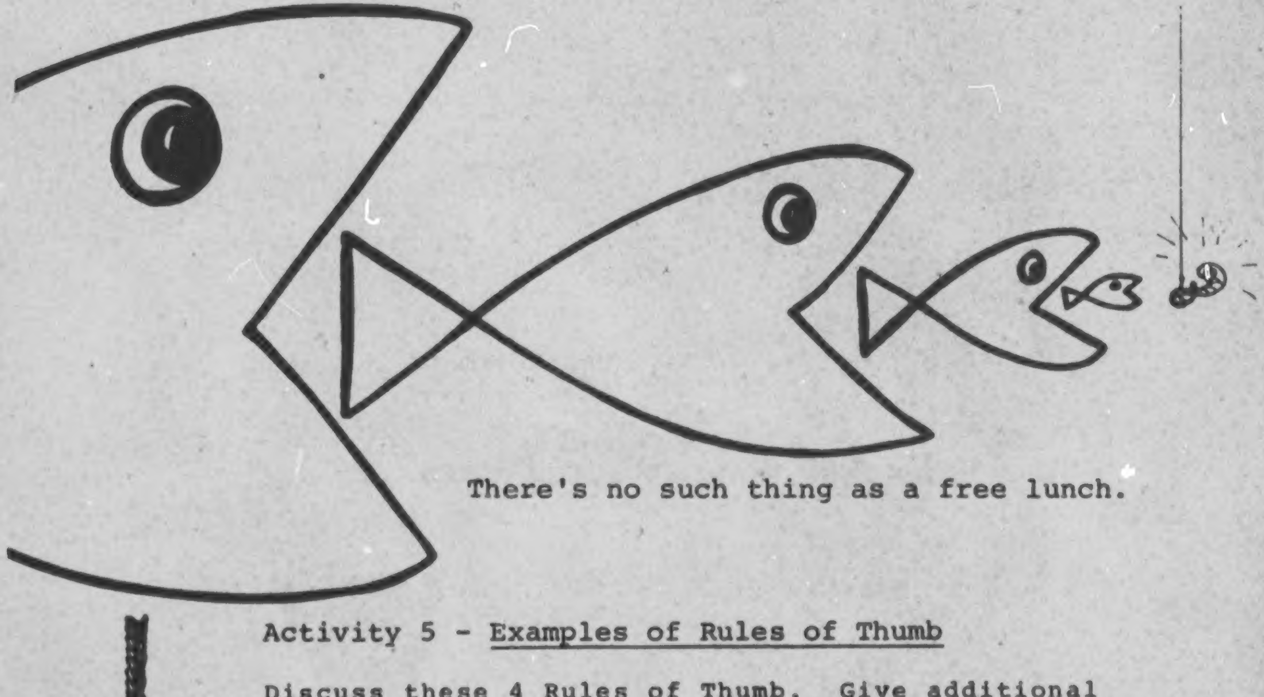
There's no away-we must live in our own wastes.

There's a limit.

18


CRUNCH
JOE, LET'S GO TO OUR RANCH THIS WEEK-END AND HUNT BATS AND AYUYU!
BOY, DO I LOVE ESKABECHE!
HOT WATER
POWER PLANT

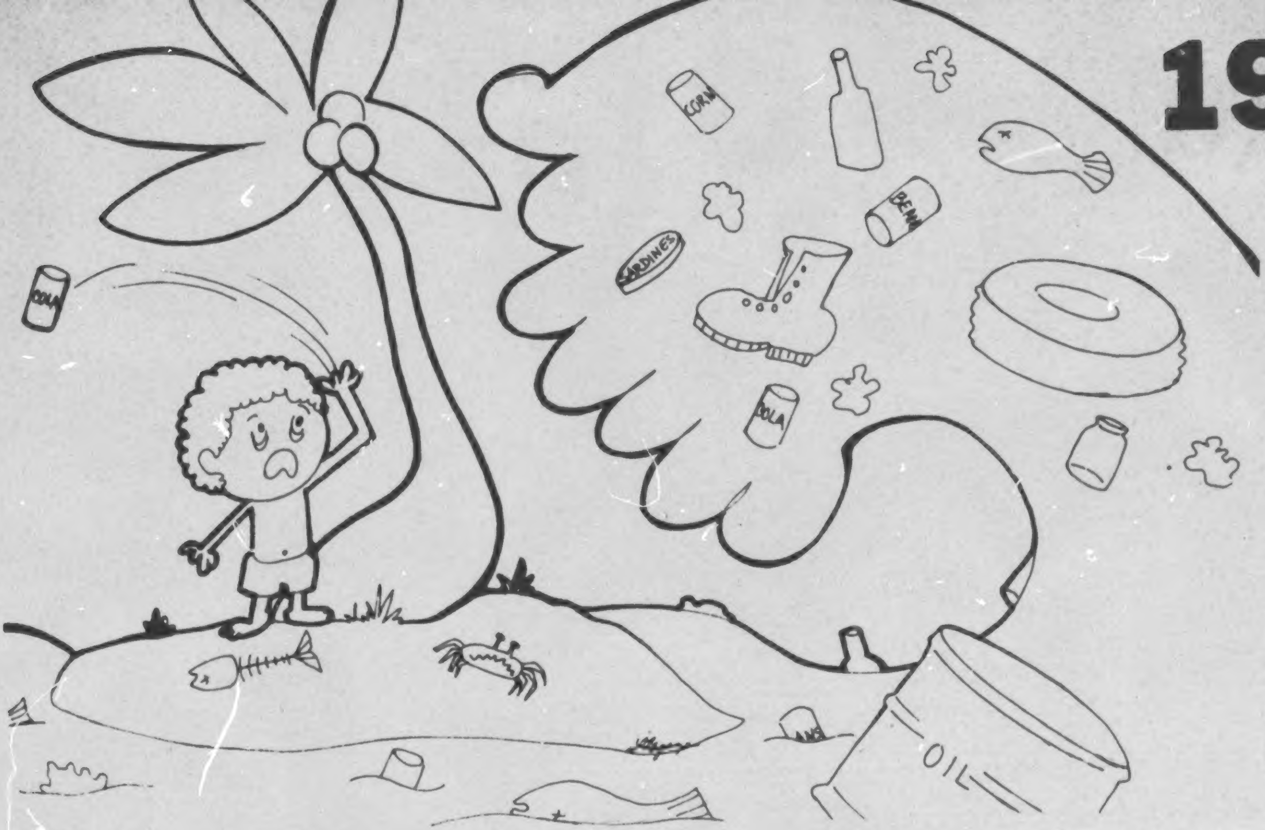
Everything is related to everything else.



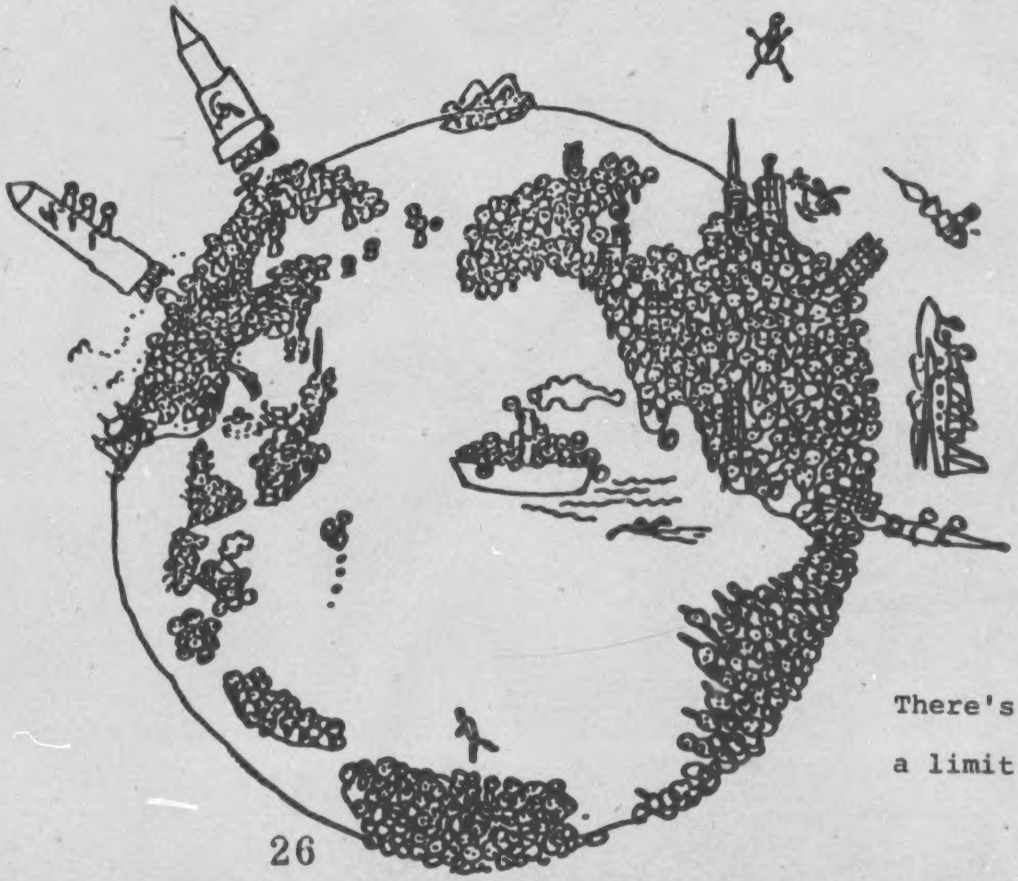
There's no such thing as a free lunch.

Activity 5 - Examples of Rules of Thumb

Discuss these 4 Rules of Thumb. Give additional examples of each. Put them in your notebook.


COLA
CORN
BEANS
SARDINES
COLA
OIL

There's no away——
we must live in our own wastes.



There's

a limit.

Preview of Section II

Let's look at our effect——our human impact——on the way nature works.

In the people-directed world, we are the selective force. We get what we want by using energy, technology, biocides, and money. These tools have made us very successful. Our success is shown in survival, increase in population and our ability to get more conveniences and luxuries.

It seems there are two groups of people: those whose success is in population growth, and those whose success is in conveniences and luxuries. Both groups are approaching their limits. Why? Because both are built on a principle of limitless growth on a limited planet, and that just won't work.

We've gotten into a jam. People who delighted in large families are being carried away by the tidal wave of their own population. They're running out of food and struggling to survive. People who delighted in conveniences and luxuries are running out of resources and into pollution. Guam is in a unique fix——people here seem to be after big families——and also lots of conveniences and luxuries. It just won't work!

We need to face reality and work on four problems, all at the same time:

1. Survival - We must have the necessities of life and avoid famine, pestilence, war and pollution.

2. Population growth - Earth is already overpopulated. We must stop population growth. It is the only way we can survive and have a choice about what to do next.

3. Conservation - We must conserve the resources, including energy, that we now have. This means wise, limited use, and recycling. We need time and resources to do what's necessary to get out of our jam.

4. Alternative technology - We must develop new, ecologically sound technological help.

To meet these problems we need knowledge, understanding and action from all. If you're not part of the solution, you're part of the problem.

II—Man's Way

Unnatural Selection

People often behave as though there were no natural laws. We change the World to suit ourselves. We help along some species, like crops, ornamentals and weeds. We select against some species like fruitbats, totot (Marianas fruitdove, Guam's official bird), and the gentle megapode, sasngat. We over-harvest them, destroy their habitat, introduce other species that kill them off, and pollute them to death. We replace natural selection with human selection.

Our tools for selecting include energy from fossil fuels, technology, chemicals for biological warfare, and money.

Fossil Fuels - Long ago, some plants and animals living on Earth died. Natural processes changed them into coal, oil, and, many geologists believe, natural gas. All three contain stored energy which we have learned to release. The energy is used for heating and cooking, to make electricity, to run railroad engines, boats and ships. Oil is converted into lubricants and fuel for cars, buses, trucks, planes. Coal and oil are used to run steam turbines and are mixed with other things to make plastics and synthetic cloth.

Modern Technology - Fuel-consuming machines are great and do many things. They relieve us from a lot of drudgery. They let us get ahead in agriculture. Before machines, food was raised by people's hard work (sometimes by slaves) and by using animals. A lot of this food went to feed the workers. Machines don't eat human food. They do require fuel, however, and that's the catch. (There's no such thing as a free lunch.) Coal, oil and gas deposits are limited. They're running out now and you may live to see the day when they are no more. Consider the implications.

Activity 6 - Life Without Fossil Fuels

What would life on Guam be like without oil, diesel, kerosene and gas? List some things we would have to do and some we wouldn't be able to do.

Biological Warfare - Pesticides, medicines, food additives, and other synthetic chemicals——with these tools we kill off species we don't want in or around us. Such poisons have been very effective in helping us win out over other species. Remember, though, that everything is related; what affects other living things affects us directly or indirectly. Remember too, that cooperation is a principle of the natural World.

Money - It has an interesting place in the man-made world. It acts like stored energy. It has the power to make things happen, good or bad.

Money allows people to get away from subsistence work like farming and fishing to keep alive. Money makes it easier to get things not produced on Guam. Money distinguishes developed from underdeveloped countries.

Money fools people into thinking that the World is run by money rather than by energy from the Sun. As a result, many people misplace their sophistication and try to be smart but concentrate on the wrong things. Instead of taking care of the natural World that supports them, they end up damaging their life support system in order to get more money.

We must learn to keep better account sheets of what we get and what we lose with money's energy. One great challenge is to turn the power of money to ecologically sound uses.

Activity 7 - Life Without Money

Discuss what your life on Guam would be like without money. In your notebook write a short essay after the discussion.

The result of using our four powerful tools—energy, technology, biocides, money—is that the human population has survived and grown. Also our standard of living has risen. Today many people enjoy a lot of conveniences and luxuries. Unfortunately we are not like natural populations. They have built-in mechanisms for limiting their population growth in relation to their resources. Our growth has run away with us. Let's consider:

Our Exploding Population

The major environmental problem is that the human population keeps growing at a faster and faster rate while the size of the Earth remains the same.

Today 4 billion people live on Earth. Every two seconds 5 babies come into the World. While you're reading this paragraph about 30 babies will be born. By this time tomorrow there will be 216,000 more people on Earth. In the next year there will be 79,000,000 more.

The Earth has about 1.5 billion hectares of land that can be economically cultivated. This amount remains the same.

Perhaps 20 million people will starve to death this year. That's hard to imagine. Let's look at it on a smaller scale.

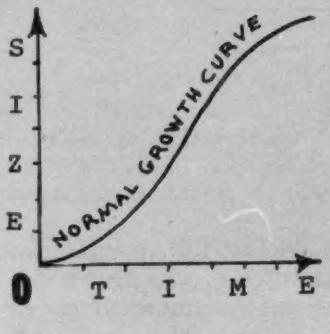
Activity 8 - Dividing Up Land

Do this activity with a buddy——one of you be Juan and his family, the other, Roberto and his family.

There are three conditions: Juan and Roberto have the same amount of land. Every generation the land is divided equally among the children. Every generation Juan's family produces 2 children, Roberto's, 8.

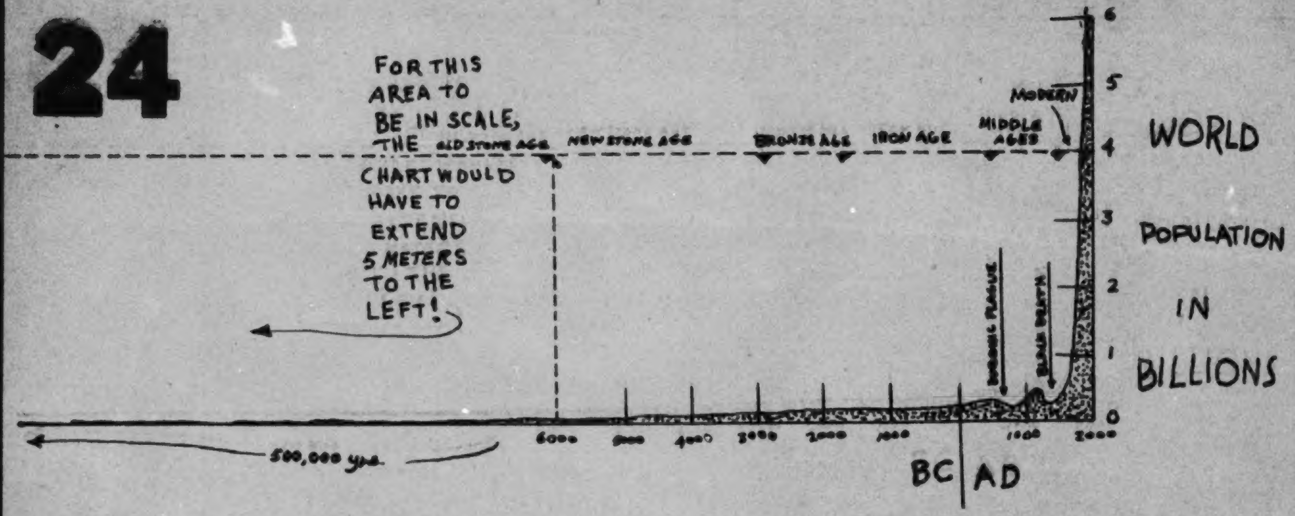
1. Juan and Roberto, each take an equal-size sheet of paper, representing your land. Mark your paper and tear or cut it equally for your children——Juan 2 pieces, Roberto 8.
2. Now become Juan Jr. and Roberto Jr. Pick up your one piece of land apiece. Divide the land, Juan Jr. in half, Roberto Jr. in eighths.
3. Now become Juan III and Roberto III. Again divide the land so that Juan IV gets half of Juan III's land and Roberto IV one-eighth of Roberto III's.
4. Any comments?

On a graph, the curve of normal growth of any organism or population shows a slow beginning, then a period of rapid increase (babies grow fast) followed by a levelling off. It looks something like a stretched-out letter S and its name, sigmoid, means 'S-like'. (Sigma is Greek for S.)



The human population has been growing for 500 thousand years. How many years have you been growing? Human population growth is graphed on the next page. This shows a slow rise at first because small populations grow slowly. Once the population is bigger though, it grows faster and faster.

24



Do you think this curve will ever level off? Why? When?

The human population rate of growth increases as the population increases. People who study population talk about 'doubling time'——the time it takes a population to increase by 100%, to double. Here are figures for Earth's people:

Table I

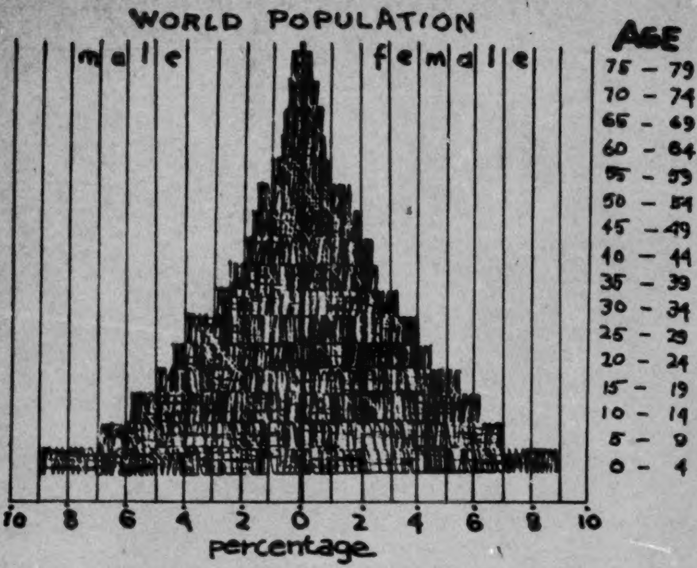
Date	Estimated World Population	Doubling Time (yrs.)
8000 BC	5,000,000	1,500
1650 AD	500,000,000	200
1850	1,000,000,000	80
1930	2,000,000,000	46
1976	4,000,000,000	35

Activity 9 - World Population Graph

Look at the World population graph above. How long should the horizontal axis be? About how long is the modern period? By how much has the population increased during modern times? World population today is 4 billion. About how much is it expected to be by 2000 A.D.?

Why are we in this population predicament? Because of success in lowering our death rate. Population growth is equal to birth rate minus death rate. Death rate over the years has been due to 3 main things: Sickness, war, and lack of food.

Mankind has become very efficient at raising food. We use machines and fertilizers and cultivate much suitable land. We have developed great bargaining systems to avoid war. We have been successful in fighting sickness. The human death rate has decreased greatly.

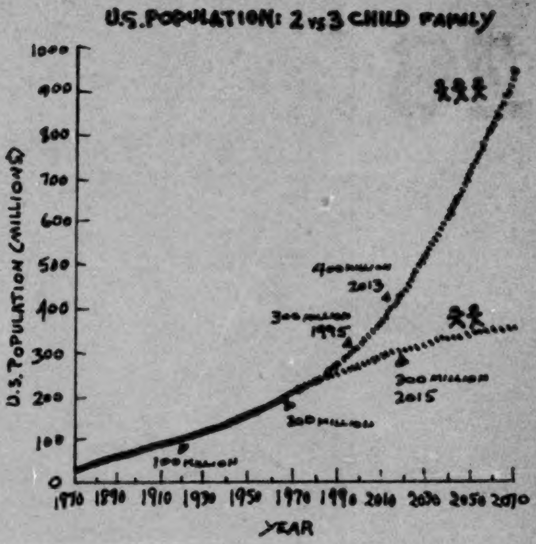


Many more people are being born than are dying, and the human population is increasing. The more children, the more parents there will be to bear even more children. A population pyramid for the World is shown here.

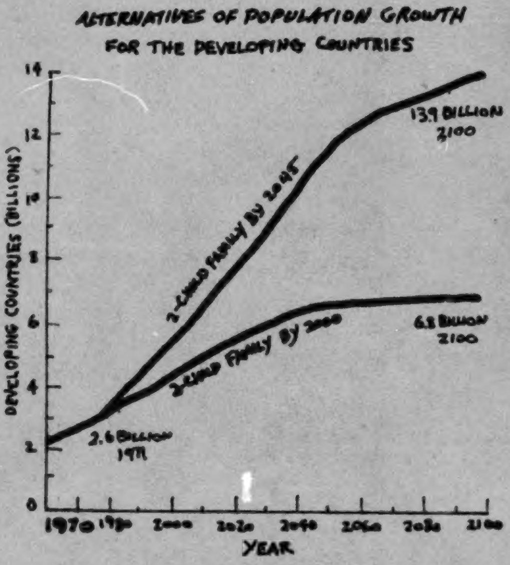
Note that each age group in the pyramid is wider than the one above. Fifty-four percent of the World's population is under 20. When this big group grows up and has children, we will have the biggest baby boom of all time! Even if young marrieds just starting to have children have only two, they will produce as many more people as now live. Even then the population will rise for some time before leveling off.

Here's a graph showing what would happen in developing countries if by the year 2000 the family limit is 2 children. Their population would rise to 6.8 billion by 2100.

If they wait till 2045 to adopt the 2-child limit, it will mean 14 billion people by 2100!



This graph shows what will happen in the United States if families have 2 or 3 children in the future. Notice that if each couple has 2 children, the population will rise for awhile. See the big difference in population growth that a third child per family makes!



Guam's Population - Nine babies are born on Guam every 24 hours. At one time the death rate here was higher than now, and there were fewer people to start with. In 1950 there were 230 deaths and 1,737 births. In 1975 there were 441 deaths and 3,163 births. Over the past 25 years Guam has averaged 8 times as many births as deaths. Subtracting deaths from births, we find that the population increase in 1950 was 1,507, and in 1975, 2,722.

In additon to the Island's high birth rate, more people come to Guam than leave; this also adds to our population growth.

graphs: from
Commission on
Population,
Growth, and
the American
Future.

Let's look at this population over the ten years from 1960 to 1970.

GUAM POPULATION	
1970	86,926
1960	67,044
Increase	19,882

Guam's average increase during this time was about 3% per year. At this rate, the number of years it would take for Guam's population to double is 35 years. Thirty-five years from 1970 is the year 2005; how many years is that from now? (The Bureau of Planning's 1976 figures indicate a new doubling time, of 21 years. When is that from now?)

Can you imagine twice as many people here? Twice as many people in rooms, on school buses, in stores, living in houses, trying to get enough to eat, competing for jobs, looking for a place to wash, sleep, park, get away from it all...?

How old are you now? How old will you be in 2005? If our growth rate stays the same and you stay here, you'll see what it's like having twice as many people on Guam. That's one way to look at it. There's another way. In 2005 you will have had your children. Hey, doesn't that mean that it will be your generation that doubles Guam's population——if it is to double? It's up to you to decide whether Guam's population doubles according to statistical prediction. Maybe it won't. It's up to you.

Activity 10 - Our Population

Copy and complete Table II (next page) in your notebook.

1. Graph Guam's population from 1901 to 2005. Determine the population density and add to your table.

2. Add Guam's population density to Table II. To get the density, divide the island's total land area, 560 square kilometers, into Guam's population. For example: The population in 1901 was 9,676.

$$\begin{array}{r} 17 \\ 560\overline{)9,676} \end{array} \text{ people per km}^2.$$

3. What might Guam's population density be by the year 2005?

TABLE II

Year	Population	Diff.	%Increase	Density (people/km^2)
1901	9,676			17
1910	11,806	2,130	22	
1920	13,275	1,469	12	
1930	18,509	5,234	39	
1940	22,290	3,781	20	
1950	59,498	37,208	166	
1960	67,044	7,546	13	
1970	86,926	19,882	30	
2005	173,852*	86,926	100	

(*Statistical prediction based on growth rate)

Overpopulation - This might be defined as the number of people in excess of:

1. The number of people who can live well, in peace, and in healthy, beautiful surroundings.

2. The number of people who can permanently be supported by the biosphere on a strained basis (to the limits of Earth's carrying capacity).

3. The number of people who can temporarily be supported by an endangered biosphere.

Which definition do you think makes the most sense?

We fit the third definition of overpopulation. Earth now has 4 billion people, more than its carrying capacity. We live today by:

> Using up non-renewable fossil fuels; polluting air, land and water; interfering with natural cycles; decreasing complexity; and by destroying fellow life forms.

Our population explosion cannot continue. There's a limit. There's not enough space or food, there aren't enough resources. The population explosion combined with modern technology has created a pollution explosion. This explosion threatens food production at a time when we need more food. Pollution also diminishes life's quality and increases likelihood of illness.

We will not conquer famine, war or pestilence until we control population. Our choices are:

Die of starvation, of war, of sickness,
or
Control our population and live.

Activity 11 - Sharing In Hard Times

On Guam there is a very nice custom of not eating without first offering food to one's companions. Write in your notebook what you think may happen as population and the cost of food go up and availability of food goes down.

Birth Control - Medical technology is lowering the death rate. This is a benefit to mankind. Lowering the death rate, however, leads to our population explosion. Now we come to the second half of the great package deal, birth control. In order to keep from exceeding the resources of Earth, we need to limit births.

Birth control has arrived late. Earth is already over-peopled. Perhaps birth control will spread in time to avoid much more human suffering.

What You Can Do:

1. Admire quality in a family rather than how big it is.
2. Write your local newspaper, radio and television stations suggesting they feature the population problem.
3. Go to hearings about population growth. Support political candidates concerned with population problems and environment.
4. Get information on the problem. Show friends. Write:

The Population Council
245 Park Avenue
New York, NY 10017

Population Reference Bureau
1755 Massachusetts Ave. N.W.
Washington, D. C. 20036

Zero Population Growth
1346 Connecticut Ave. N.W.
Washington, D. C. 20036

5. When you marry, have no more than two children.

Environment and Life Style

Environment is closely related to life style——the way we live. Environment and technology shape the way we live. The way we live determines what the environment will be like.

Most creatures of the Earth live restricted by what they must do to survive and reproduce. What a plant is like is determined by how it manages to get the right amount of sun, water and nutrients and how it reproduces. An animal is shaped to get its food. Plants and animals are involved almost totally in surviving. Only mankind is not. Mankind is almost born free. We are so clever at surviving on this planet that we can go about living in many different ways.

Let's look at some characteristics of different ways of living.

Subsistence - Subsistence means having only the bare necessities for life. People with a subsistence life style spend most of their time getting food, water and shelter for themselves.

There are two general types of subsistence life style. One is independent, the other dependent. The first is found among people with traditional, respected cultures. They provide for themselves honestly and self-sufficiently. The dependent people lack a strong culture and life style, and cannot provide for themselves without help. They try to get what they can any way possible. Often they depend on gifts.

Discuss some places where these ways of life occur.

Conveniences - Some examples: Stoves, washing machines, school buses. (No doubt your parents have told you how they walked to school when they were your age.) Conveniences contribute to comfort. They make life easier.

Conveniences give us more choice of how to spend our time. Washing machines give people the time it would have taken to do the laundry by hand. Then people have time for something else.

Luxuries - Luxuries go beyond conveniences. They make things easier and more comfortable, but are not necessary. They're often expensive or otherwise hard to get. It's partly a state of economics and mind. A convenience to some is a luxury to others. For instance, paper towels——use once, throw out. Some people use rags for wiping up, and wash and reuse them. They buy paper towels only on special occasions as a luxury.

The problem with having conveniences and luxuries is that they use up natural resources and energy and produce a lot of pollution. As an example, using a lot of paper towels means using up a lot of trees, because paper is made from trees. It also contributes to the air and water pollution produced by paper mills. Conveniences and luxuries are nice, but consider the amount of resources and energy they use up. Consider the pollution produced in their manufacture.

One modern danger is that we get used to necessities. Then we take them for granted and start thinking that conveniences are necessities. Then we get used to having conveniences and start thinking of luxuries as mere conveniences. When this happens we have a much greater impact on our environment. Worse, we lose perspective and don't realize how well off we are. We are in danger of becoming more consumptive and destructive. Poor people don't have this problem. They can't afford conveniences and luxuries. Rich people have a choice. A wise person can distinguish among necessities, conveniences, and luxuries, and whether or not they are worth the cost.

Activity 12 - Necessities, Conveniences, Luxuries

List 5 necessities, 5 conveniences and 5 luxuries. Across from each describe the resources and energy needed to make or to use it.

Whether we have conveniences and luxuries is determined by what's available, and what's important to us. What's available to us is determined partly by the state of 'development' of our country. What is important to us is determined by our own preferences and the society and culture we live in.

Two Groups - One group of countries, the 'developed' ones, including the United States, Japan, most of Europe, and Russia, uses up most of the World's resources and produces most of its pollution. The United States, for example, with only 5.5% of the World's population, uses up about 35% of World resources. and produces about 50% of its pollution! Because they consume and pollute too much, the developed countries should probably be called the 'overdeveloped countries'.

The second group hasn't concentrated on technology and continues to desire large families. This group's populations are increasing rapidly. The countries where they live don't have a choice about the way to live. They must struggle just to support their exploding populations. Only a few of their people have conveniences and luxuries. Many lack even necessities. Until their rapid population growth is stopped these countries will never be able to provide necessities and conveniences for their people. Even then they won't rise to the level of consumption of developed countries. Developed countries already have used up more than their share of World resources. There's not enough left to go around.

Here's a chart of some characteristics of developed countries and underdeveloped countries (those with mainly subsistence living) and Guam:

Table III

Characteristic	Developed country	Underdeveloped country	Guam
1. agricultural system	commercial	subsistence	partly commercial, partly subsistence
2. rate of population growth	low	high	high
3. literacy	high	low	high
4. production	high	low	low
5. income per capita	high	low	high on a World scale
6. consumption per capita	high	low	high on a World scale
7. agricultural and industrial pollution	high	low	increasing

What grabs you about this table? People of the underdeveloped World are very impressed with the large incomes and high consumption of developed countries. Today, people who don't have conveniences and luxuries can see people who do. This makes the have-nots also want to live a consumptive life, and they lose appreciation for their own way. That makes it tough because not enough resources exist for everyone to consume as much as people of developed countries do. A consumptive life has a lot of requirements and costs. Some of the requirements are listed in characteristics 1-4: Efficient, commercial agricultural systems require large inputs of fertilizers, pesticides and energy-using machines. These systems discourage variation, and that's bad. They use a lot of energy and put a lot of poisons into the environment.

In order to develop, a country must have a low population growth rate. Otherwise, all its work to get ahead has to go to feed the people. It takes literacy to forge and maintain the technology needed for high production. High production requires a lot of resources, raw materials and energy. So far, its by-product has been more pollution than we can tolerate.

The impact we have on our environment is determined not just by our population size but also by our way of life. If this involves consuming lots of energy and materials and making a lot of pollution, we will have a lot bigger impact on our environment. We might think of our environmental impact as a sort of equation:

Population size x Way of life = Environmental impact

Underdeveloped countries overwhelm the Earth with huge populations. Developed nations overwhelm the Earth with high levels of consumption and pollution. The ingredients on the left are very different, but the results to the right are the same:

Huge population x Subsistence life style = Big impact.

Small population x Consuming polluting life style = Big impact.

Where Guam Stands - Guam is in a curious situation. As you can see in Table III, it is like developed and underdeveloped countries. It is high in literacy, per capita income and consumption, but has a rapidly growing population and low commercial production.

The reason for this paradox is that Guam is supported by money and other help from developed countries. Guam is a territory of the United States, one of the World's richest countries. The money pumped into this Island has had a tremendous impact on Guam's natural environment and life style.

Changing Life Style - Years ago when life here was Chamorro, there was no money from outside. The island provided what was needed. In those days one's ability to do practical things well was important. In those days a man probably gained importance by being capable and generous. The more he could do or give, the more he got, if not in material things, then in respect.

Then came the discovery of Guam by outsiders, and the discovery by Guam of outside goods. New things like nails and fusiños and machetes became available. Nowadays we have money, block houses, and cars. Outside wealth and goods have freed people from limitations of island resources. With new things available, a new trend started: 'I want one of those too', and 'keeping up with the Cruzes' began.

Although giving and sharing here are still important, owning and consuming things also influence how people feel about themselves and each other.

When affluence arrives on our shores, we see nice things that we hadn't even thought of before. Wants arise in our throats and we lose patience with life on Guam. We drop our own life style and start to copy the consumption-pollution life style of others. Many people put the cart before the carabao. They look down on the 'old' way of life and try to live as if they were rich rather than by doing things that would truly enrich and develop life here. Many people seem to believe that the rest of the World is unlimited and very rich and that the main thing to strive for is to open the faucet so that more riches may pour into Guam from the outside. We don't realize that the rest of the World, too, is really limited and not so rich.

Guam has changed from a subsistence to a consumptive, paycheck life style. The change has had a big impact on environment and on people's values. It makes a man important for what he can buy instead of what he can do with his own hands and mind. It also tends to make people forget to take care of the Island, its natural beauty and biological productivity.

Guam is fortunate. Because we don't have to produce a lot to support ourselves, we don't have all the pollution that goes with production. Some day we may have to produce more. Now is the time to start protecting what we have, while Guam is still green and beautiful with blue sky and we have so much help from outside.

> 'Don't it always seem to go
> That we don't know what we've got till it's gone.
> They paved Paradise and put up a parking lot.'
>
> Joni Mitchell, 'Big Yellow Taxi'

If we pause and look at life on Guam with perception, perhaps we can regain some patience and adopt a more reasonable life style suited to our Island, rather than a false image of unlimited riches.

Good luck, tomorrow's Guam is yours!

Activity 13 - Wants Re-examined

On your next trip to the store, list some things there you would like to buy. When you get home, think about each item. Across from it put a check if you could create something that would serve the same need.

Discuss values of the items with your class. Try to make the ones you want yourselves.

Wait a week. Then go back over your list and circle the things that you still want.

Activity 14 - Appreciating Guam

The way we spend our leisure time has a lot to do with our impact on Guam.

List some things you do for fun that are wasteful or damaging.

List some fun things to do here that won't hurt the environment.

Share the lists with classmates, other friends, teachers, and parents. Then go out and have fun!

Activity 15 - Nature Appreciation

Spend one hour, alone, in a forest, savanna, mangrove, reef, or other wild place.

In your notebook write where you went and what impressed you.

Pollution—A Threat To It All

Life's not just a matter of earning money and going to the store to buy some food to eat. A lot of interlocking natural happenings are necessary as well.

These happenings can be influenced in several ways. One way is pollution.

How Many Kinds Of Pollution?

Look at the picture. What's going on here?

Notice the tipped-over garbage can. Many people think of pollution as garbage. It is one problem but there are others.

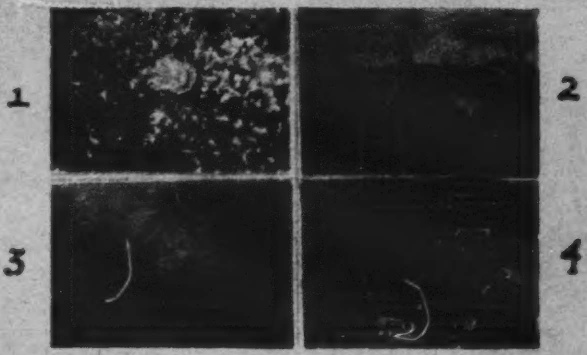
Cabras Island power plant is in the background. Have you ever been downwind of these smokestacks?

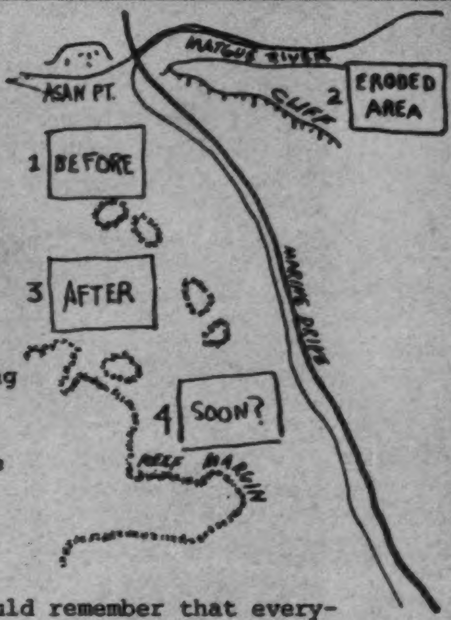
A third form of pollution is barely noticeable. The shore and lagoon are muddy. Inside the reef here is a habitat for corals and fish. It's a good place for snorkeling and scuba diving. In 1973 a piece of land across the road and up the hill was bulldozed. Bare soil was left exposed there. Rains eroded the soil, carrying it downhill. It washed into the lagoon alongshore. Silt clouded the water and cut down sunlight. Without sunlight algae don't make the normal amount of themselves. Without enough algae to eat, fish and other animals don't have enough food.

Inside many corals are tiny algae that help the corals live. Without sunlight these algae die and the corals get weak. Coral animals filter food from the water and help keep it clear.

For centuries natural ocean currents have been sweeping southward around Asan Point carrying bits of reef debris. The lagoon is adjusted to this continual slow addition. If big amounts of silt suddenly cover delicate coral tentacles, many corals and their algae die at once.

Silt has killed several corals in the lagoon. Many have survived. Go snorkeling here and see for yourself the effects. This form of pollution is worse than the two others shown in the picture because it seriously affects not only the beauty of the lagoon but its biological productivity.





Who would have thought that bulldozing land out of sight up the hill would have such a result! Who would have thought that those plants holding the soil on the hill had something to do with keeping the lagoon waters clean and productive!

Someone should have thought. We should remember that everything we do has an effect on everything else and is related to everything else. Then we'd seriously and responsibly consider the environmental impact of our actions. Damage such as this could be avoided. Our World, as a living process, must be treated with care.

Activity 16 - Film: Cloud Over the Coral Reef

See the film if you can. Discuss siltation. In your notebook list some examples of siltation on Guam. The Guam Environmental Protection Agency is aware of them. What can the EPA do about them?

Kinds of Pollution

Pollution can be split into two major types: those directly threatening life, and those allowing pest species to multiply.

The first category includes biocides——generally called pesticides——other poisons, heavy metals, and radiation. These are unseen, most damaging, and a danger to human life. Because they are unseen, they are generally out of mind. People don't seem very concerned about them.

They should be our first concern.

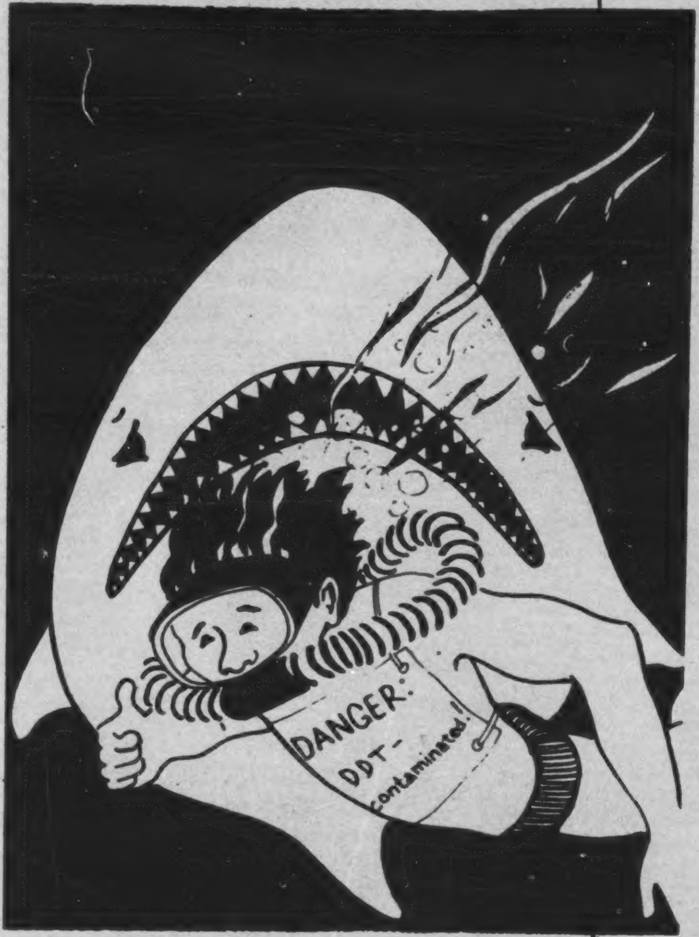
The second category takes in things like flies on food, wastes in the water, and garbage where it isn't wanted. People tend to get upset over these visible kinds of pollution. The danger of such pollution is that it provides conditions for pest species to multiply. These species include micro-organisms that cause sicknesses like typhoid fever, dysentery, dengue and hepatitis.

Biocides - These are 'killers of life'. We generally call them pesticides, meaning killers of things that bother us. That's not a good name——it makes us forget that what can kill one form of life may also harm others. Few pesticides will affect or kill only the species they were intended for.

Some biocides are produced naturally by plants. Examples are nicotine from tobacco, rotenone from tuba (bagin, Derris elliptica), saponin from puting (Barringtonia asiatica), and pyrethrin from the chrysanthemum.

Most man-made biocides have been invented within the last 25 years. We haven't had time to find out their long-term effects.

One main group of man-made biocides includes the chlorinated hydrocarbons. These chemical compounds are related to DDT——dichloro-diphenyl-trichloroethane, $(ClC_6H_4)_3CHCCl_3$——a colorless contact insecticide, toxic to man and other animals. Chlorinated hydrocarbons kill by over-exciting the nervous system of an insect so that the animal goes into convulsions, becomes paralyzed, and dies. DDT is more effective on insects than on people because it goes through their skin easier. We get DDT into us in many ways, however, including through the food we eat. Fishes and other water life are especially vulnerable to the poison of chlorinated hydrocarbons.



Let's consider the characteristics of one chlorinated hydrocarbon, DDT, in the light of some basic ecology:

1. The Biosphere - DDT is not a natural part of the biosphere, it is a man-made poison.

2. The Water Cycle - DDT co-distills with water; that is, it is not left behind with other impurities when water evaporates. It circulates with water through our water cycle and life systems.

3. The Carbon-Oxygen Cycle - DDT slows down photosynthesis, the process which gives us our oxygen.

4. The Energy Cycle - Green plants capture only about 0.0005% of the Sun's energy that gets to Earth. Slowing down photosynthesis makes this tiny percentage even smaller.

5. The Nutrient Cycle - DDT is not easily biodegradable. Worse, it harms many organisms which break down dead materials.

6. Food Chains and Webs - DDT travels along in these and bioaccumulates, concentrates, in fats.

7. Productivity - DDT reduces natural biological productivity.

8. Carrying Capacity - DDT reduces biological carrying capacity.

9. Complexity - DDT is used to maintain simple ecosystems like agriculture crops by getting rid of species that compete with man for the food. It is believed to contribute to the decline of some endangered species like the American bald eagle whose reproduction is reduced as a result of exposure to DDT. A small percentage of individual pests are immune to this poison. Their descendants become immune to increasingly stronger doses of DDT while natural predators on the pests are wiped out.

So many effects of DDT are now known that the U.S. Environmental Protection Agency has banned its use in the United States, Guam and the Trust Territory. DDT is still used in other parts of the World, however. Some relatives of DDT like benzene, hexachloride, lindane, isodrin and toxaphene are not yet banned.

Other biocides are the organophosphates. These are related to the nerve gas poison developed during World War II. They make the nervous system overactive; an animal dies twitching and out of control. In general, organophosphates are not long-lived. They break down and do not build up in tissues or show long-term effects. In small amounts, however, they are highly poisonous.

Alternatives to Pesticides - The American agricultural system uses a lot of biocides. Biocides help us get higher yields of food and other crops. Now we are learning more and more about their high biological costs (there is no free lunch). People are becoming more interested in alternatives to biocides. Are there ways to control pests without using biocides?

Yes, here are some:

1. Use of resistant crops. Plants not affected by certain insects and diseases don't have to be sprayed. Many resistant varieties are now available. Many long-time local crops are relatively resistant to pests. You don't often see suni (taro), bananas, dagu and nika (yams) or mendioka killed by pests. It's mainly the recently introduced crops that need a lot of protection from pests.

2. Mixed planting. If gardens contain a variety of crops, plant-specific pests have difficulty multiplying. This is because there isn't enough of one particular food to allow the population of a pest species to grow very large. Many Guam farmers prefer mixed, varied plantings.

3. Fast harvesting. If food crops are harvested as soon as they are ready and not left around there will be fewer pest problems.

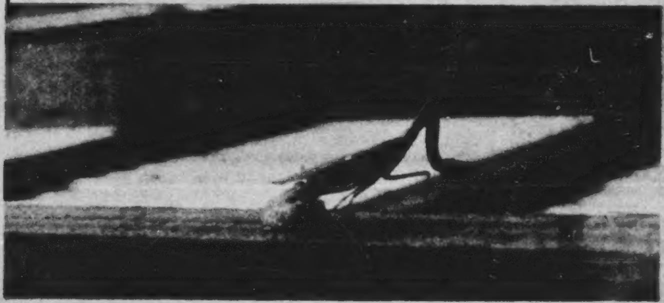
4. Companion planting with insect-repelling plants. Insects are disgusted by some plants like onions and garlic. It helps some if you grow these next to plants that insects normally like.

5. Picking insects off. In small gardens some insects can be controlled by hand-picking. Remember, insects have short activity and breeding seasons, so it's not like you'll have to be picking during the whole growing season.

6. Non-poison sprays. Sometimes soapy water works about as well as poison sprays——try the least harmful method first.

7. Biological control. This is quite an effective means of controlling pests without poisons. There are a number of approaches:

a. Natural predators. Insects like praying mantises, which eat other insects, help control pests. You can often find praying mantis egg cases attached to sticks and twigs. Provide a protected place for the young and you'll be doing your bit to control pests naturally. Here's a picture of a praying mantis and her egg case on a piece of house lumber, and one of some baby mantises on a garden shrub.



b. Introduced predators and parasites. Sometimes predators are introduced intentionally. An example in Palau was the introduction of a wasp to help control the destructive coconut rhinoceros beetle. On Guam, introductions include a Lantana bug to control the spiny Lantana weed, and cannibal snails to get after giant African snails. (See Savanna, Old Fields, Roadsides.)

c. The sterile fly program. The melon fly, Dacus cucurbitae, is a pest of crops in the cucumber family. In 1968-69 it was nearly eradicated from Guam. An attack on natural reservoirs for the fly (e.g. the atmogoso vine) was combined with a special program at the Department of Agriculture. Melon flies were raised in the laboratory where they were sterilized by radiation. They were then released over the Island from a low-flying plane. When wild flies mate with sterilized lab flies, the eggs don't hatch. Female melon flies mate just once in their lifetime, so gradually the melon fly population declined——tricky, huh? The program was dropped as it was about to achieve 100% success.

The alternatives mentioned above and others are good ecology. But not all of them are as efficient, effective and convenient as biocides for big agricultural operations. There is increasing pressure to provide enough food for today's great population. It is unlikely that a switch from biocides to alternative methods will occur overnight. Let's try to minimize the use of biocides. Let's adopt as many ecologically sound methods of pest control as possible.

Do you or your family use any biocides? Can you use fewer of them? Perhaps after trying other methods, you still must use a biocide. Choose one from a biological source, such as rotenone, rather than a chlorinated hydrocarbon. Use of biocides can be reduced if they are applied efficiently without wastage.

Activity 17 - Sprayed or Slightly Damaged Fruit?

Which would you prefer to buy:

A fruit with a little insect damage that has not been sprayed with a chlorinated hydrocarbon pesticide, or

A fruit with no insect damage that has been sprayed with a chlorinated hydrocarbon pesticide?

Discuss your choice.

Heavy Metals - Lead, mercury, cadmium, arsenic and other heavy metals are poisonous or may produce poisons if we absorb them. Some of their effects can be extremely dangerous.

Lead - We now think that lead contributed to the fall of the Roman Empire. Just before the first century A.D., Rome's ruling class used lead containers for food and drink. We read that these people had ailments now known as symptoms of lead poisoning, including sterility, stillbirths, and brain damage. High amounts of lead have been found in some Roman bones.

You could get lead poisoning on Guam from lead-based paints. They're no longer made in the United States but are used a lot here. The main source, however, would probably be exhaust from cars using special or premium gas. This expensive gas has lead compounds added to cut down on engine knock. The compounds get into the air by way of the exhaust. The exhaust from one car puts 1-2 kg of lead into the atmosphere each year.

Mercury - Between 1953 and 1960, 52 people in Minamata, Japan, died of a then-mysterious ailment. Another 150 suffered serious brain and nerve damage. These people had eaten fish which contained mercury compounds absorbed from factory wastes in the water. Additionally, 23 babies were born with nerve and brain damage.

Mercury is used in fluorescent street lights and in fungicides used to treat seeds before planting. Plain liquid mercury isn't poison but evidence shows that some sea and freshwater micro-organisms convert it into a poison. Earth and the ocean floor have a lot of mercury. It tends to concentrate in the flesh of big ocean fish. (If your mercury thermometer breaks, collect the liquid and take it to a science teacher.)

Cadmium - In 1955 cadmium intake caused a serious disease in Japan. Between 1955 and 1968 at least 100 people died from cadmium poisoning. The symptoms include great pain in the joints and disintegration of bones.

On Guam the main source of cadmium may be car exhausts.

Arsenic - Arsenic is famous for poisoning.

In Palau a man died soon after he drank a small amount of the weed killer sodium arsenate. Using this agricultural herbicide is now against the law but some old supplies may still be around. If you find any, advise the Environmental Protection Agency.

Cases that get a lot of attention are rare. Usually the effects of heavy metal poisoning are not even noticed until it's too late. They include an increased tendency toward diseases like cancer and heart problems. They may just weaken a person. The worst kinds of pollution may well be the ones which gradually wear down the quality of life without our realizing what we're losing.

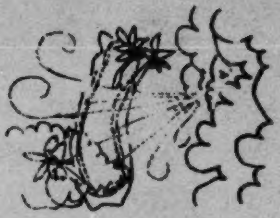
Radiation - You probably know that everything is made of molecules and that molecules are made of atoms that are made of protons, electrons and neutrons. Holding these parts of an atom together takes a lot of energy. When the parts break up, a great deal of energy is released. This energy can bomb DNA and change its structure. DNA is the 'blueprint' in cells. It determines what an organism will be like. When DNA is changed, more than likely something will go wrong. A person may develop some kind of cancer, have a shorter life, or produce an abnormal child. DNA is short for deoxyribonucleic acid.

In the Pacific we are quite familiar with radiation. The planes that dropped atomic bombs on Hiroshima and Nagasaki took off from our neighbor island Tinian. Formerly, the United States tested nuclear weapons in the Marshall Islands. On March 1, 1954, a change in wind direction during such a test on Bikini resulted in the accidental contamination of many Marshallese. One died several years ago probably as a result of radiation-induced sickness. A Japanese vessel, Lucky Dragon, was illegally fishing 100 miles north at the time. It was covered by radioactive coral ash from the accident. The crew did not know they had been contaminated by radiation until they began getting sick on the way back to Japan. Several of them died and there was a great scare about radioactive fish. This resulted in studies which traced radioactivity all the way from the Marshall Islands nearly to Guam. You may read about it in the book, *Voyage of the Lucky Dragon*, by R. E. Lapp.

The people of Bikini and Enewetak have not been allowed to return to their homes. Those atolls became contaminated with radioactivity. The U. S. doesn't conduct tests in the Pacific any more, but the French continue nuclear testing in Tahiti.

On Guam there's been talk about a nuclear power plant here. If an actual proposal is made in the future, people will have to weigh carefully the benefits of having more electric power against the real danger of a nuclear accident.

The public doesn't know if radioactive materials for military use are stored here.



Air Pollution - We are fortunate to live on an island. Our separation from the rest of the World, our sea breezes and small size usually prevent air pollution from building up to where it is obviously irritating.

We do have some air pollution. Commonly, it's coral dust irritating to our respiratory system. Quarries, asphalt plants, and traffic over unpaved roads cause the dust. Most other kinds of air pollution come from burning, either in the open or in internal combustion engines.

Open burning includes burning trash, military oil fires for fire-fighting practice, and grass fires. People who smoke pollute their own lungs and contribute to others' discomfort with nicotine, tars and hydrocarbons.

The greatest source of air pollution is exhaust from internal combustion engines in cars, airplanes, buses, motorcycles, heavy equipment, boats, power plants and other machines that use petroleum fuel. A lot of these machines are around. The car is the major offender, but power plants probably make the most noticeable fumes. On calm days a cool layer of air forms a 'lid' over Tumon Bay before the cliff. Fumes from the Tanguissen power plant collect like a smog (smoke + fog). You can see them and smell them. You can get a stronger smell of sulfur dioxide downwind of the Piti power plant. You can even feel it as the sulfur dioxide combines with the water in your nose, bronchial tubes and lungs——your respiratory tract——to form sulfuric acid. Perhaps you noticed the hazy smoke over Agana in September, 1975. It lasted about 3 days while the wind pattern was reversed and fairly still. The next time winds are southerly, look for this haze over Agana. Where does it come from?

Internal combustion engines produce pollutants: carbon monoxide, sulfur dioxide, nitrogen oxides, hydrocarbons and particulates——small bits of solids.

Carbon monoxide (CO) crowds out the oxygen in your blood and has the same effect on your body as losing blood. A single car motor running for a few minutes in a closed garage produces enough CO to kill a person. This gas has no odor, so you can't tell when it's around except from symptoms of poisoning. A traffic jam of cars can produce enough CO to cause headache, poor vision, loss of muscle control, and make you feel sick. Sulfur dioxide (SO_2) is believed to increase problems of asthma, bronchitis and emphysema. Nitrogen oxides have similar effects. Hydrocarbons and particulates have many different effects and probably increase the incidence of cancer.

One problem with air pollution is that it may not be noticed right away. Sometimes it just weakens people and makes it harder to keep well.

Some parts of Earth are dangerous to human life because of air pollution. These include some large cities like Los Angeles and Tokyo. In London, during the two months following a five-day black smog in 1952, 12,000 more people than usual died.

Besides being directly dangerous to people, air pollution threatens the chain of life. It reduces the amount of sunlight getting to plants. Plants are the beginning of the food chain for all life. Burning of all sorts increases the amount of carbon dioxide in the atmosphere. Some scientists think it may eventually act like a sheet of glass and keep heat near the Earth.

No matter how isolated it may be, no place on Earth is free from air pollution. We all share one atmosphere. Pollutants added in one place today travel someplace else tomorrow. There is no away.

Activity 18 - Testing The Air

Clean the windshield of the family car and then notice how soon it gets dirty again. Clean it in the afternoon and leave it parked. Next morning, run your hands over the glass and look at it from different angles. If you live where there's a lot of airplane traffic, you may find an oily film that smears into a rainbow haze. What is it?

Activity 19 - Smoking Mosquitoes

Test the effects of smoking on mosquito larvae in water. They come to the surface to breathe. Take two babyfood jars half full of water and place the same number and size mosquito larvae in each. You can catch the larvae by sucking them up into a large straw. Have the teacher blow plain air into one jar and cap it tight. Then the teacher blows smoke from a filterless cigarette, or from one with the filter cut off, into the other jar, and caps it, too. Mark the two jars and place them on the corner of your desk or on a shelf and observe them from time to time. Write down any differences in the larvae in the two jars.

Water Pollution - Without water animals die. On Guam our water comes from two main sources: wells in the north, and surface water in the south.

Guam uses about 10 billion gallons of water every year. About 64% of this water comes from wells dug in the limestone northern part of the Island. Water from wells serves the north as well as Yona, Ipan, Talofofo, Inarajan and possibly in the future, Merizo. Well water comes from rain which has percolated down through the porous, sponge-like limestone. It collects into a freshwater lens. (See Geology unit Ch. 7.) A water lens is something like an underwater lake in a rock sponge at about sea level. Freshwater floats on top of saltwater in the porous rock and some of it runs out into the ocean along the coast. You have probably noticed this freshwater at places along the shore. It is generally cooler than the seawater and looks blurry as it mixes into the saltwater.

Wells in northern Guam go down to the freshwater lens. The water is chlorinated and pumped to many parts of the Island. If all goes well, this water is replaced by rain seeping down into the lens. If we pump out too much water or it doesn't rain enough, the pump will start bringing up salty water. Then it will be too late to conserve the fresh. How much freshwater reserve do we have in the lens? We are still trying to find out. One thing is certain: The reserves don't increase, and Guam's population does.

Water has a hard time sinking into limestone that has been packed down or covered with asphalt or houses. The lens here isn't replenished as much as it once was.

Another problem with our water lens sponge is that it can absorb things other than water: oil, seepage from garbage, biocides, radioactivity. If stuff that won't break down naturally gets into the water lens, it's difficult and expensive to remove it. This has actually happened at Harmon where oil still contaminates well water 30 years after the airstrip was discontinued.

Marine Waters - Four main kinds of pollution of Guam lagoons and inshore waters are: thermal, oil, sewage discharge, and siltation.

Thermal Pollution - This happens when too much heat is released in the wrong place. Whenever we use energy we produce waste heat. In some big cities, where a lot of energy is used, waste heat actually changes the city's climate. If we continue to use more and more energy, waste heat released into the atmosphere will eventually affect climate over large areas.

Heat pollution of parts of the sea is a more immediate problem. Heat speeds up the life processes of organisms——their metabolic rate. It also decreases the level of oxygen dissolved in water. At a time when marine organisms need more oxygen than usual, less is available. Many fish and other organisms go somewhere else. Those that don't may die.

Guam's main source of thermal pollution is power plants. They produce a lot of heat. Their machinery is cooled by pumped-in seawater. Did you ever notice the channels leading to the Piti and Tanguissen power plants? Seawater goes into the plants, picks up waste heat and is then discharged back into the ocean.

The University of Guam Marine Lab studied heat outflow from Tanguissen power plant. When the plant first started up, nearby coral was killed in an area of about 3,000 m^2. Lab tests showed that corals die when the temperature rises 4°C above normal. The hottest temperature the corals could stand was 32°C. Seawater went into the plant at 27.3°C and came out at 33.8°C. Thermal pollution was probably responsible for killing the corals.

Other marine life was also killed by the hot water. The scientist on the study recommended that the hot outflow be piped into deeper water where it wouldn't do so much damage. If the effluent isn't put into deeper water, more inshore plants, coral, and other animals may die and their skeletons break down and get washed away.

The World is running out of petroleum and there has been some talk about a nuclear energy plant for Guam. This kind of power plant produces even more heat than those burning petroleum products. If a nuclear power plant is built here, we can expect a greater problem than we now have with thermal pollution of our waters.

Oil - Oil pollution puts black film on the water and blackens beach sand. Big spills kill many water birds. An oil spill's really hard to clean up, and miserable to swim in. It takes a long time to break down.

The effect of spilled oil on marine life varies with the type and amount of oil, and the location. Oil spills in the Trust Territory show that mangroves are especially susceptible to oil damage. Guam's mangrove flat at Apra Harbor could be damaged by oil. Besides killing mangrove trees oil kills some shellfish. The ones that don't get killed may taste oily. Bottom-living organisms are killed when they become coated by oil at low tide. In one study, corals covered with it died from the increased heat absorbed by the black oil. If detergents and other chemicals are used on the spill, even more marine life is damaged.

Oil spills on Yap resulted in blue-green algal blooms (lots more algae growing). Children who swam in the polluted water complained of itchy skin. The slime produced by coral and other marine life attracts oil. A number of fish feed on the slime. The oil thus gets into the marine food chain.

We still have a lot to learn about oil pollution. On Guam it is not yet common. Our oil spill regulations are strictly enforced. In our neighbor islands in the Trust Territory enforcement is not so strict, and there are a lot of problems with oil. Sometimes, ships go aground on reefs of uninhabited islands. Some of these are turtle rookeries where sea turtles go to lay their eggs. Sea turtles are threatened species and only a few rookeries are left. To lay their eggs sea turtles return to the island where they hatched. How they manage to find their way back is unknown. It would be a great shame if oil pollution interfered with their delicate homing sense.

'Endangered Species Conference'

Oil spills seem unavoidable. Two cases close to home show this. One occurred after the first load of oil was pumped to the Guam oil refinery. Company officials had said that a spill was impossible. The second case concerns the repeated oil spills near the Coast Guard Loran Station on Yap. These spills occurred despite repeated assurances from the Coast Guard, who are themselves in charge of protecting our coasts against oil spill pollution! In both cases people had the best intentions——but accidents do happen. In Palau, a supertanker port may be built. If this happens you will surely hear more about oil spills in Micronesia.

Sewage and Other Organic Wastes - It's unpleasant to swim in water which has human and other animal wastes in it. One big problem is pollution of marine waters with sewage. If there are fresh wastes from people sick with, say amoebic dysentery or hepatitis, these sicknesses can be passed on to swimmers who swallow the water. Most organisms living in us can't live in sea water, though, so this kind of pollution danger doesn't last long.

If a lot of sewage-nutritious water or other organic wastes are dumped in one place, it may cause another kind of problem. Organisms which decompose organic wastes use up oxygen. If too many wastes are put in one place, too much oxygen is used up. Organisms like fish and shellfish can't live there. This condition is 'eutrophication', a poor term since it means 'good feeding'. What we mean to say is more like 'overfertilization', 'rottenizing'!

The old way of disposing of sewage was to let toilets empty into an underground septic tank. The wastes decompose and become mostly water full of nutrients that plants need to grow. This water overflows from the septic tank through pipes into the ground. Problems arise if the ground already holds too much water. If too much water and wastes are put into a septic tank it overflows before the wastes are completely decomposed. If too many septic tanks are in one area, the ground may not be able to absorb all their outflow. This could lead to health problems, especially if broken water pipes are buried in contaminated soil.

If wet soils are saturated with nutritious water, underground eutrophication may occur. This may be what has happened along Tumon Bay. Before so many hotels were built there, you could dig in the sand just below the water's edge and it would be white. Today this sand is gray and smells a little like rotten eggs. That smell is hydrogen sulfide.

The water currents around planned sewer outfalls should be carefully mapped before construction to make sure that the effluent will spread out over a reasonable area. This would be especially important if the sewage treatment plant should break down. Why?

So far, it seems cheapest to dump the effluent from sewage plants into the ocean. Someday we may realize it's better to make use of such nutritious water for land and water farming. It's been done in Asia for centuries.

Other Things That Get in the Water - Through the sewage system, or by runoff from the surface, all sorts of things can be washed into our marine water. Some of these, including agricultural chemicals, can be poisonous.

Some effects of freshwater on the marine environment are discussed in the Introduction to the *Mangrove Flat* unit.

Solid Wastes

It is easy to understand the solid waste problem. During an average day each person on Guam throws away 1.5 kg of trash. This amounts to 64,000,000 kg of trash per year! If you add the wastes from business and government the amount nearly triples. If all this waste were piled on one acre of land, it would make a stack more than 300 meters high every year! That's almost as high as Mt. Lamlam.

The amount of trash generated on Guam has grown fast because of our rapidly growing population and modern way of life. In the past, most wastes were biodegradable——they decomposed into basic soil nutrients. Today most trash is non-biodegradable. Things like aluminum, rubber and plastic won't break down. They just pile up. Where will we pile them?

We don't like to live with trash so we throw it away. The big problem is that there's no away. Guam is small and all our land is needed today or soon. When we just dump trash in an open dump, we spoil the place for many uses. It's not pretty. It provides a breeding place for rats, flies and mosquitoes. It's not healthy. If the trash is burnt, the smoke isn't nice or healthful either. Some plastics even give off poisonous fumes when they burn.

Sanitary Landfills - Rather than just dump things in the open and burn them, we use sanitary landfills. These are places where large amounts of garbage are buried. This should do away with burning. Also, covering the garbage with dirt prevents mosquitoes and rats from breeding in it. Sanitary landfills require a bulldozer. A trench is dug and trash is dumped into it. Then the bulldozer covers it with dirt. After the trash is covered with soil, the place may be used in many other ways. You'd never know it was a dump.

This Island now has 4 sanitary landfills. GovGuam operates one at Ordot, and there are three on military land, at Andersen, Naval Air Station, and Naval Station.

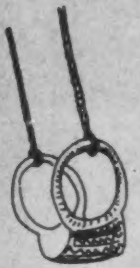
Sanitary landfills don't exist without some problems. Garbage might contain some dangerous, unhealthful contaminants. Rain running into the ground might carry these substances with it. The water flowing into a stream might pollute it. If the landfill is in a limestone area, the bad water could flow down into the lens and foul our main water supply. The three military dumps are built in limestone areas. Because of the danger of polluting our water supply, these dumps eventually will have to be closed. The problem is to find other satisfactory locations.

The Ordot landfill is so full now that it can't be covered over every day; burning the trash is now (November 1976) a daily practice. Ordot dump will soon have to be closed. After it is completely covered over, it may become the new site of the Department of Agriculture. Solid waste planners at the Guam Environmental Protection Agency are now looking for another dump site. This will be hard to find.

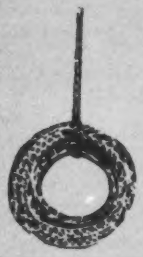
Trash Pick-up - Besides needing sanitary landfill, we have to get the garbage to the dump. To do this the Government of Guam provides household trash pick-up, paid for with tax dollars. Businesses haul away their own trash or hire collectors. GovGuam provides trash pick-up twice a week for garbage and twice a year for larger things like old cars and refrigerators. In spite of this, some people throw their trash in open dump areas around the villages or along the road. This is against the law. We now have a big fine for littering.

The only legal place for civilians to dispose of trash is in the Ordot dump. In the future the government may provide large containers in several places where people may not be reached often by the public pick-up service.

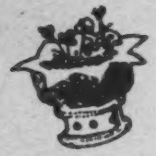
Throwing Away Less - One partial solution to the solid waste problem would be to throw away less and recycle. We could sell aluminum cans as scrap metal to be used again. We could use old tires for plant holders or swings or fish homes on the reef. Some communities burn trash in an incinerator using heat energy to make electricity. Organic wastes can be used for fertilizer. Garbage could be cut up fine and layered into compost with plant leaves, animal waste, soil, moisture, and earthworms. Any trash we couldn't use again could be squashed together by a machine.

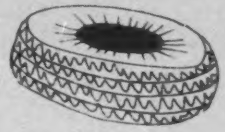


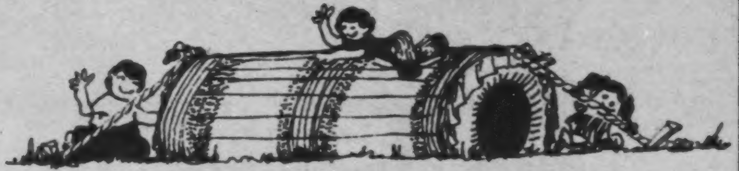
The Can Tax - To help meet our trash problems, the GEPA has asked the Legislature to set up an environmental protection fund, using money from a tax to be placed on aluminum cans. Some of the money collected would be used for solid waste programs, and some would be refunded to people who turned in empty drink containers at collection centers. This would help stop littering and get people used to the idea of recycling. Find out what happened to the can tax bill and why.



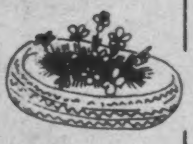
Hazardous Wastes - They are poisonous, explosive, or radioactive. The military deals with explosives. At present Guam hasn't a good way to deal with poisonous and radioactive things. The federal Environmental Protection Agency has developed guidelines on how to handle hazardous wastes of different kinds.

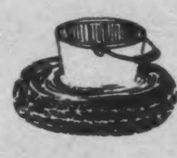




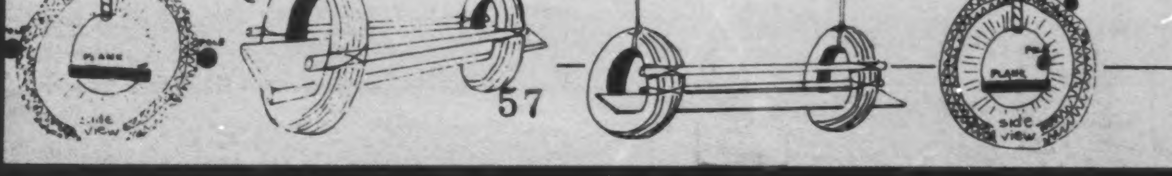


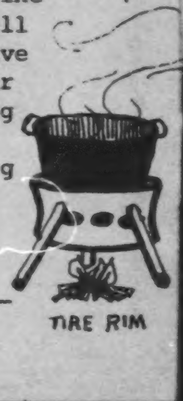
A Recycling Idea





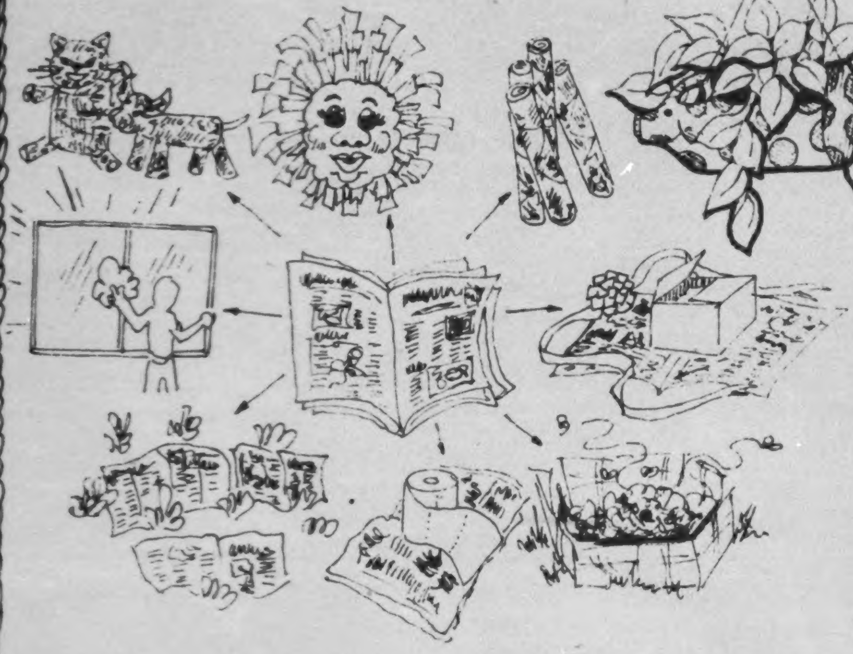
Sharing Subscriptions - Arrange a magazine exchange in your neighborhood. This will save money on subscriptions and also save trees from becoming magazine paper. Our magazines arrive late anyway, so getting yours by sharing with a neighbor won't make that much difference in their being up to date.

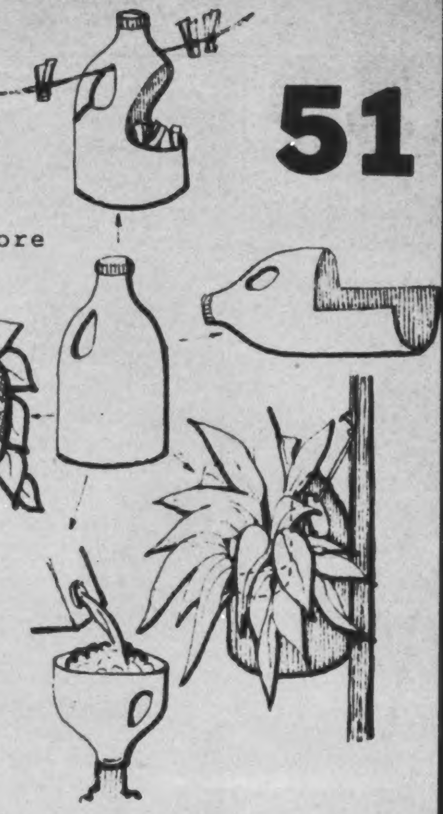


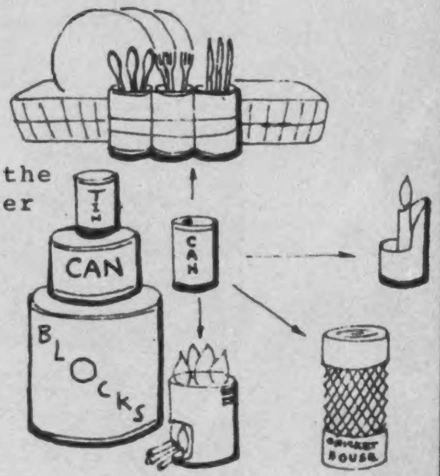


Activity 20 - Recycling Junk

Make something out of junk. Here are some more ideas. Better yet, make up your own.





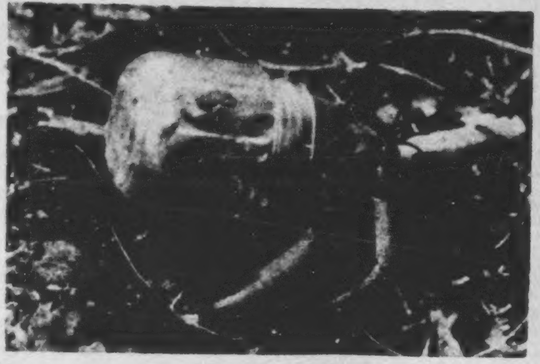


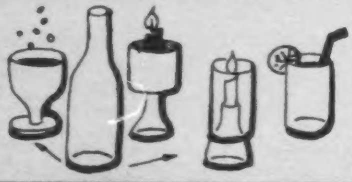
We can't pretend that you're going to solve the solid waste problem with this activity. After all, we can use only so many candle holders, glasses and swings! However:

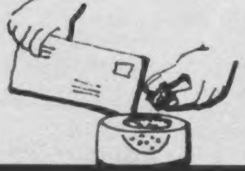
You'll have fun using your ability to re-use things instead of spending money and using them up.

You'll be doing something that doesn't hurt the environment and helps by utilizing a little solid waste.

Mainly, you'll plan for recycling. From now on you can look at 'junk' as material to be used in some way. Recycling will become more and more important in the future. Maybe you will come up with some really good ideas that will help us all be more like Nature and recycle the resources of our World.







Noise Pollution - On our neighbor island Palau, people greet each other in the morning with 'Ungil tutau'. Tutau is a bird that calls softly in the morning.

On Guam you can hear birds announce the coming dawn if you get up in the quiet and cool of the early morning before most people wake. If you live in an air-conditioned house, you'll have to go outside. If you don't wake up in time, bird sounds will be drowned out by noises of cars, radios, lawnmowers, airplanes, banging garbage cans, eggbeaters, flushing toilets, crying babies and motorcycles.

Is it noisy here? A weekend at the ranch, or camping, will offer a chance to find out.

Too much noise is a form of pollution. Noise gets on your nerves and can also cause permanent hearing damage.

How Noise is Measured - Noise is measured in decibels. From the following chart, you can get an idea of the number of decibels produced by different sources, and their effects. (After Ehrlich and Ehrlich)

Table IV

Kind of Noise	Decibels	Description or effect of long exposure
Breathing	10	Very quiet
Whisper, rustling leaves	20	
Quiet library	40	
Quiet talk in quiet home	50	Quiet
Conversation in restaurant	60	Intrusive (you hear other noises whether you want to or not)
Clothes washer, average factory, noisy office	80	
Diesel truck	90	Hearing damage (8 hours)
Jet at 1,000 feet, outboard motor, power mower, motorcycle, (25 feet)	100	Serious hearing damage (8 hours)
Live rock music	110	
Thunder, jet takeoff	120	Human pain threshold (when it starts to hurt)
Jet takeoff at close range	150	Eardrum ruptures

What Too Much Noise Can Do - The American Medical Association says that noise can cause physical and psychological damage—— that's to your body and your mind. Some of the effects are shown on the chart. Notice how many common noises are above 60 decibels. List some noises above 90 decibels that you hear—— never, very rarely, occasionally, or often.

Hearing damage makes it hard to understand what others are saying. For a person with hearing damage it is also difficult to speak clearly. This can cause misunderstanding and more problems. It may even make someone seem less intelligent than he really is.

Activity 21 - Effects of Hearing Loss

Your teacher may give you some paragraphs to read while a tape is played. The tape shows how people hear and speak when they have different amounts of hearing loss. It also shows how background noise affects a hearing-damaged person's ability to distinguish words.

Activity 22 - Hearing Noise (Choose one)

Get up early in the morning before the sun is up. Sit quietly outside. Write down the sounds you hear. How do they make you feel? Sit in the same place about 10 A.M. if you're doing this on a weekend; about 5 P.M. if on a school day. Again list the sounds you hear. How do they make you feel?

Spend a weekend at the ranch or out camping. List the sounds you hear there. How did you feel about them? When you return home, list the sounds there. How do they make you feel?

Bring your lists to class to compare and discuss.

What You Can Do About Noise - Noise pollution can be cured. It just takes doing. Here are some ways to reduce noise:

1. Make sure your family car has a good muffler and tailpipe, and that any family motorcycle has good baffles and muffler.

Repair these when necessary. If your parents can't get a new muffler or tailpipe right away, you can make temporary repairs yourself by tying an open can or other piece of metal around the hole. Just remember this is a temporary measure; it won't last very long.

Broken tailpipes and mufflers may allow engine exhausts to enter your car. Remember, these exhausts may contain poison gases. Fix the muffler or tailpipe so the exhaust will at least be directed away from you.

2. Remind other people to repair their mufflers if necessary. There's a law against noisy vehicles.
3. Fix noisy things so they are quiet.
4. Use quiet things instead of noisy ones.
5. Turn down the volume of your amplifier and radio.
6. At quiet times, don't do noisy things like power-mowing the lawn. Making noise when it's quiet is more annoying than making noise at noisy times.
7. Plant trees and shrubs——they absorb noise.
8. Speak softly.
9. Do things quietly.

Activity 23 - Cutting Down on Noise

Add to the list 5 more things you can do to cut down noise. Then do them.

Activity 24 - Environmental Villains

Make a 'wanted' poster for an environmental villain. Include a fitting fine for the polluter and a fitting reward for the person who captures him. Example:

'INAS ICE BOX OPENER'

WANTED for opening the ice box too often thereby heating it up and wasting energy to cool it again.

FINE: Has to drink warm lemonade for 2 months.

REWARD FOR CAPTURER: Cold lemonade for 2 months.

What 'They' Are Doing

Guam has one agency to look after its environment. This is the Guam Environmental Protection Agency (GEPA). In March 1973 it became an independent organization and now has about 40 employees including senior biologists. Its office and lab are at Harmon. The work of the GEPA is regulated partly by a board of directors of 9 citizens nominated by the Governor and confirmed by the Legislature.

At present GEPA operates programs for air and water quality, solid waste and waste water management, and pesticide control. It also assists in Islandwide planning.

GEPA has established water quality standards. Water quality is checked regularly to see if it meets these standards. When it doesn't, GEPA tries to get whoever is responsible to correct the situation. Part of the water-monitoring program is testing for coliform bacteria. These bacteria live in the colon, our intestine. They are not harmful but when a lot of them are in water we know that it is contaminated with human wastes and maybe other bacteria that could be harmful. Results of the water-monitoring program are announced frequently in the newspaper, on radio and on television.

In the air pollution control program, air quality is monitored; when it is polluted, the agency tries to get those responsible to correct the problem. In the solid waste program, GEPA is trying to close down illegal dumps and improve techniques of solid waste management.

Making GEPA Work - GEPA also welcomes citizen complaints about pollution. If you see a problem, let the agency know.

GEPA is small and hard-working. It has made some progress in combating pollution, but an awful lot remains to be done. GEPA can do only what it is allowed to do by law, and it must have a good court case to stop a polluter. This takes a lot of work and good evidence. GEPA also has the difficult task of being a government agency which has to control pollution by other government agencies. This takes careful work.

One strength of the American system is that it checks itself. People on the Mainland who have realized the great impact of pollution there are willing to help us prevent the same things from happening here. Most support for GEPA comes from the federal Environmental Protection Agency funds. Until they experience pollution, it's hard for people to appreciate how serious a problem it is. By then it might be too late to correct it. The only way we can assure that GEPA grows strong enough to do everything it should is to give it our support.

Environmental Impact Statements - Environmental considerations are extremely important to planning. Guam comes under the National Environmental Protection Act (NEPA). Environmental Impact Statements are required before beginning construction using federal dollars. Such statements must include: a description of the planned action; its environmental effects, including those on endangered species, irreversible effects (that can never be corrected); effects which use up nonrenewable resources; and alternatives to the planned action.

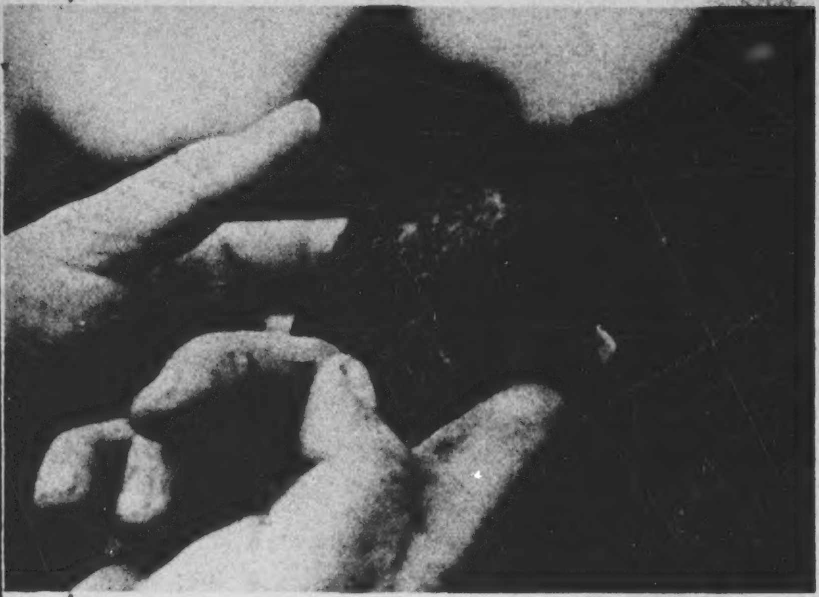
Environmental Impact Statements are supposed to bring out the environmental effects of planned actions so that the public and government agencies may weigh advantages and disadvantages. They give us a chance to decide whether a planned action is worth any environmental damage it might do. The process includes public hearings after a Preliminary Environmental Impact Statement (PEIS) has been filed. The PEIS is supposed to be available to the public and hearings are supposed to be advertised. The hearings are open to everyone.

Making NEPA Work - The NEPA is a good law but it won't work unless concerned citizens and government agencies take part. You can make it work. Watch for announcements of public hearings. Sometimes these are written in hard-to-understand language. If you don't understand what an announcement is about, call the GEPA or one of its board members and ask for it to be explained. When you've heard about the planned action, tell your friends and learn as much as you can about it. The facts should be available in the PEIS. Ask for the main points of the PEIS to be announced in the newspaper, on radio and T.V. When you have the facts, weigh the action's benefit against any environmental losses. Decide as a citizen whether such an action should take place. Then go and express your views at the public hearing. Don't be afraid. This is a good citizen's responsibility. Citizen action is important and effective. As an example, the polite, soft-spoken people of Yap, most of whom don't speak English, were able to stop a plan to build an airstrip on their reef where it would have done great damage. The plan now is to improve the existing airstrip where damage would be less.

What 'They' Are Not Doing - A lot more could be done to protect and improve Guam's environment. For example, no one agency looks after our natural reserves. On several occasions places supposed to be natural reserves have been bulldozed by government agencies or contractors working for the government. In such a case, it's time for citizens to speak up. Don't leave the matter up to 'them'. 'They' don't exist or may not have the power to correct a problem without citizen support.

People must show that they care, and then the 'bad guy' is likely to start being more responsible. Considering how government is organized today, citizens can't sit back and assume that their environment will be protected. They must work for it.

Our Vanishing Companion Life on Guam



This is sasngat, a megapode chick in the Northern Marianas. When it grows up, this bird will look like a cross between ko'ko', the Guam rail, and a chicken. Its name means 'big feet'. With these strong feet it makes its nest mound and digs in the soil for food. It lays large eggs and covers them with soil and humus. The decaying humus warms the eggs to the right temperature. The species is endemic to the Northern Marianas—it lives only there. It used to be here but human impact wiped out this quiet bird. Guam has lost a part of its wildlife heritage. Unless people give sasngat some protection, this endangered species will become extinct—gone forever from the Earth.

People have a lot of influence on Guam. The species we like, like crops and ornamentals, do well. So do rats and weeds and other species that like us and our environment.

Other species don't thrive in man-made environments. They are adapted to living in a certain wild place. Some are particularly susceptible to being hurt by man or his poisons. Those species aren't doing very well with us. Let's look at some.

Guam Plants - Some plants are endemic to the Marianas, living here and nowhere else. A few special ones occur only on Guam. They are adapted to Guam's unique natural conditions. They are part of the heritage held in trust by the people of Guam.

The trust is being broken. Guam's plants are being bulldozed away. Today foreign invaders cover much of the Island. Almost two-thirds of the plant species now here were introduced from someplace else (see Savanna, Old Fields, Roadsides).

Guam's Disappearing Birds - Some interesting birds may no longer be found here. These include nganga', the Marianas mallard, a duck; bako, the white-browed rail, cousin to ko'ko'; ga'ga' karisu, the nightingale reed warbler, a beautiful singer; and sasngat, the megapode.

Other Guam birds are getting rare. They include:

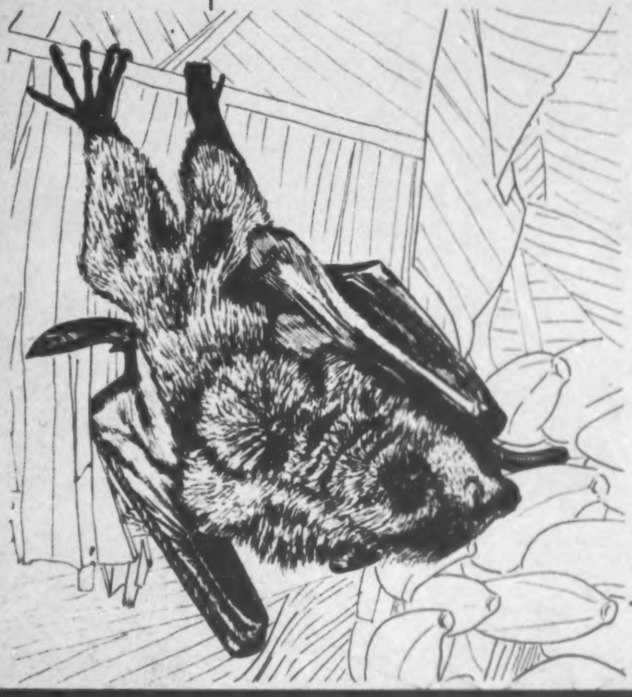
Totot, Marianas fruit dove, the territorial bird. Totot has a green upper body, green wings lined in blue, a gold-orange breast and beautiful magenta crown. Its haunting call fits the deep cool fragrant forest where it flies.

Apaka' is the male white-throated ground dove. The female is paluman fache'. Apaka' has beautiful violet colors and a white head. In his slow flight his distinctive call sounds something like 'ehhhhhhhhh'!

Yayaguak, the tiny edible-nest swiftlet. It once nested by the thousands in the cave hole at Two Lovers' Point. People used to say that it had no feet because they never saw it land. Back in the '50's you could see hundreds flying back to Two Lovers' Point about sunset.

Aga is Guam's own crow. It's a big black intelligent bird whose 'kaa, kaa' can be heard for long distances. Now it's heard less and less.

Many birds you see around your house and school are introduced species, like the sparrow and the black drongo with a long forked tail. These birds can live around people and the environment we have made. The old Guam birds can't do this and are becoming fewer and fewer.



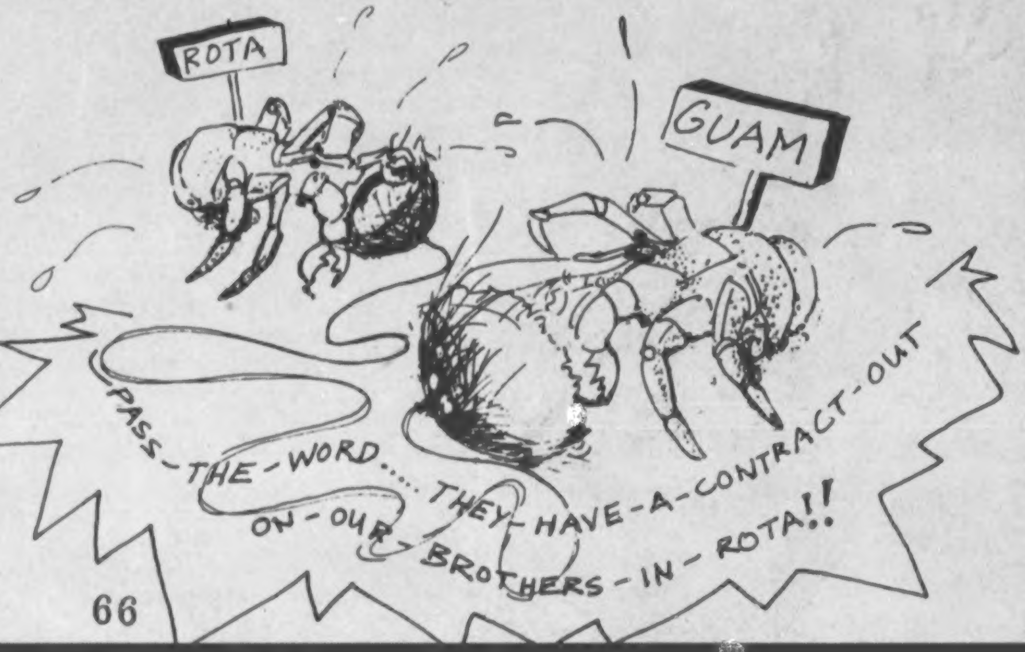
Other Animals -

Fanihi, the fruitbat, like other mammals, has hair, produces live babies and nurses them. It is a beautiful bat with large eyes. Some people like to make pets of fanihi. Its diet of fruit makes it taste sweet. Once common here, it was a favorite food for people. Fanihi flocks together. When people see a flock, they tend to think there are lots of fruitbats around. There aren't. It doesn't take a good marksman to kill a number of bats with a shotgun blast into their roosting tree. Today only a few small fanihi flocks are known. Fanihi is so rare that the people of Guam must give up their custom of eating fruitbat. Part of Guam's cultural heritage has been sacrificed to material gain by bulldozing away habitat and overhunting. Fanihi has also become very expensive in the markets. Some people import fruitbats from the Trust Territory. This could be unfair to the people there, who are also in danger of having a part of their natural heritage taken away by people who want to make easy money.

Ayuyu, the coconut crab. Ayuyu looks something like a giant hermit crab without a shell. It lives on land, eating coconut meat and other plant foods. When it lays eggs it goes to the ocean. Many people have noticed this and say that ayuyu goes to 'wash' in the ocean. The eggs hatch into swimming larvae. Baby coconut crabs don't look at all like adults. After a while, the larvae change form and come ashore. They now look like tiny hermit crabs and some even take up small shells. They keep on growing, shedding their skins for bigger ones, and change to look like the adult. At shedding time they dig a hole and stay there until the new skin becomes hard.

Here ayuyu live in the forest where there are rocks to hide in and a little soft soil in which to bury themselves when they change their skins. If you walk in the boondocks, you may see their tracks or holes and piles of the husks of nuts and seeds they have been eating.

Ayuyu too is getting scarce. You can tell how hard they are to find by the ways people catch them. When there are plenty, they can be caught in the open during the day.

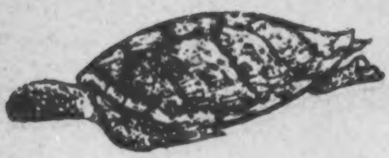

ROTA
GUAM
PASS-THE-WORD..... THEY-HAVE-A-CONTRACT-OUT ON-OUR-BROTHERS-IN-ROTA!!

When they become less common, they have to be sought at night with flashlights. When they become still fewer, they have to be lured with bait. Nowadays hunters use cans with ponne, smelly coconut meat, for bait. Even so the catch is only a few small crabs.

Ayuyu was another Guamanian specialty food. Now he also is becoming rare.

Sea Turtles - Guam has two kinds of sea turtles, hawksbill and the green. Other species are known from the Trust Territory but have not yet been reported from Guam.

Haggan karai has a hawk-like bill; the top beak overlaps the underbeak, and thick scales, scutes, are on its back. These are hunted for making turtleshell jewelry. The hawksbill is rarer than the green sea turtle, and is officially an endangered species. It is now against the law to have or sell anything made of hawksbill turtleshell.



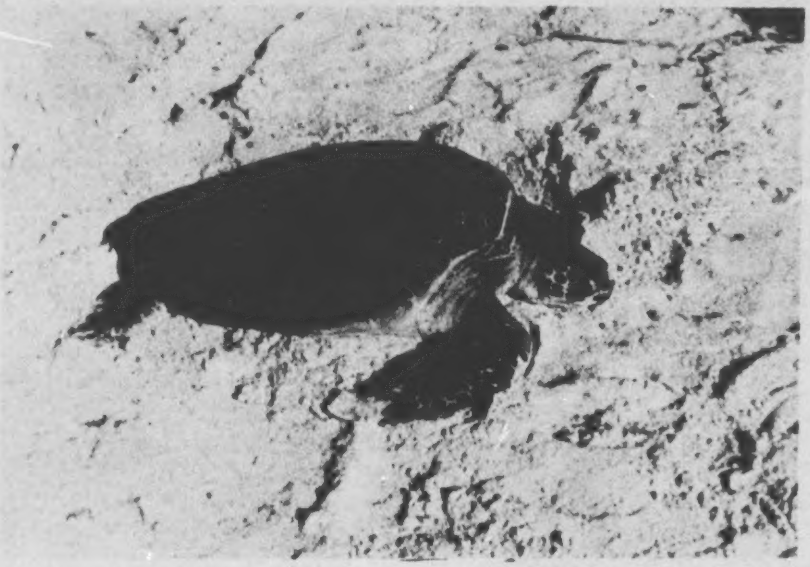
Haggan the green sea turtle isn't green. It's brown. Its beak doesn't overlap so much as haggan karai's, and it has thinner scutes on its back. At Guam we see it more often than the hawksbill but less now than formerly. Haggan is much sought after for food.

Sea turtles face a major problem. To nest they must come to land. They dig a hole on sandy beaches and lay about 100 eggs in it. They cover the hole up again and return to sea. After about 2 months, the young turtles hatch, dig out of the hole, and head for the horizon.

When the adult female comes ashore, she is helpless. It's easy to turn her over and kill her, and this is how many turtles are taken. The adult is lost with all the eggs she was going to lay. If she is not captured and the tide and wind don't erase her tracks, people may find the eggs and dig them up. So may other animals. If the eggs aren't disturbed, and the young make it to the surface, birds, people and other animals attack them. When they reach the water, many kinds of fish attack them. Only a few survive.

SLOW
TURTLE-CROSSING

On Guam, things often don't even get that far. The adult turtle is very timid about coming to land. She has to have her own undisturbed beach. People like beaches and build hotels, homes, and recreation facilities near them. Sea turtles don't even have a private undisturbed place to lay their eggs any more. It seems that we have put up a barricade against the turtles all around our shores, as if they weren't welcome.



Activity 25 - Turtle Problems

Film - 'Turtle People'
Discussion: A Test Case

It is difficult to help many species, but fairly easy to help the green turtle. Its foods——sea grass and algae——are plentiful and not much used by other sea animals. In its ocean home it is not very easy to catch. At nesting time, however, females come ashore. If we protect it then, we go a long way towards assuring its survival. This means setting aside some beaches as nature preserves. If we can protect the young from some of their many predators, their chances of survival increase. With help, sea turtles could get back into greater production.

Activity 26 - Life That Used to Be

Talk with your grandparents, or go with a friend who has grandparents. Ask these folks what plants and animals were common in earlier days. Ask about sasngat (some people say 'hasngat'), fanihi the fruitbat, and other animals and plants. Compare their abundance then and now.

If you are lucky enough to see a sasngat, most likely in the deep jungle, let it be.

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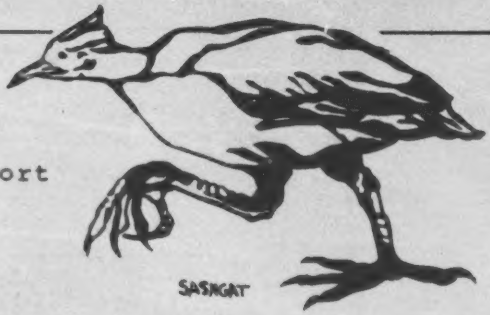
Sit quietly and watch. Learn what you can about it. Write a report and turn it in to your science teacher.



What Must Be Done - Guam has some hunting laws. Your school has copies. Look them up. Generally only a few species of wildlife may be hunted, and those only during a limited season.

Hunting laws aren't enough. Plants and animals can't live without homes. Their homes are being messed up. That we have any bats or coconut crabs left is largely because we can't drive bulldozers up and down cliffs. Most of our remaining natural habitats are on and below the forested cliffs of northern Guam. Even though bulldozers can't drive down them, they do dump stuff over the cliffs onto the forests below. We've pushed Guam's native plants and animals into a narrow strip of forest between the sea and the cliff. Unless we stop intruding, we'll destroy them completely.

People can change their environment and way of living and still survive. When things get too bad, people protest. Guam's plants and other animals cannot do this. When things get too bad, they just die out. You and your children lose the company of another expression of life on Guam.

Zoning - One way to protect habitat is by zoning. First we survey our natural heritage. Then we decide what part we should protect with special precautions to assure the survival of wildlife. Then we zone areas for specific activities. Zoning is like territoriality. It means assisting certain individuals or species to have desired resources.

It takes a lot of knowledge and good sense to zone wisely. It also takes sticking to what has been decided. We don't have a very good record on this. For example, we have a law saying that the maximum height for hotels will be 6 stories. Yet we have some hotels on Tumon Bay higher than 6 stories, haven't we? How many? How high? Zoning changes ——variances—— are often granted when money is involved. It is up to the people and their representative government to choose. If people don't like what is being done, their responsibility is to let the government know.

Nature Reserves - Natural reserves are necessary for the survival of some species. Some of these have been set aside on Guam, but we aren't doing a good

"Leave a tree or two standing. They want to call this sectl. Federiku Park."

job of protecting them. Even government and military bulldozers gnaw away at them.

Guam is included in the federal Endangered Species Act of 1973. This law provides for the protection of endangered species. The Guam Science Teachers Association printed an unofficial list of Guam's rare species in Guam Rail, May 1975. Perhaps in a few years an official list can be compiled.

Island Life

Islands are isolated. Unique species develop on them. Island people have a special trust. We are the caretakers of some of Earth's most precious life forms. Even so, of the 105 known species which have become extinct since 1600, 97 were island forms. Why do you suppose this happened?

Why Save Other Species? - There are practical reasons not to kill off other species. We need to maintain the balance of nature and a 'genetic bank'——a store of life forms from which we may one day develop new foods, medicines, textiles, dyes, or other useful things we haven't yet discovered.

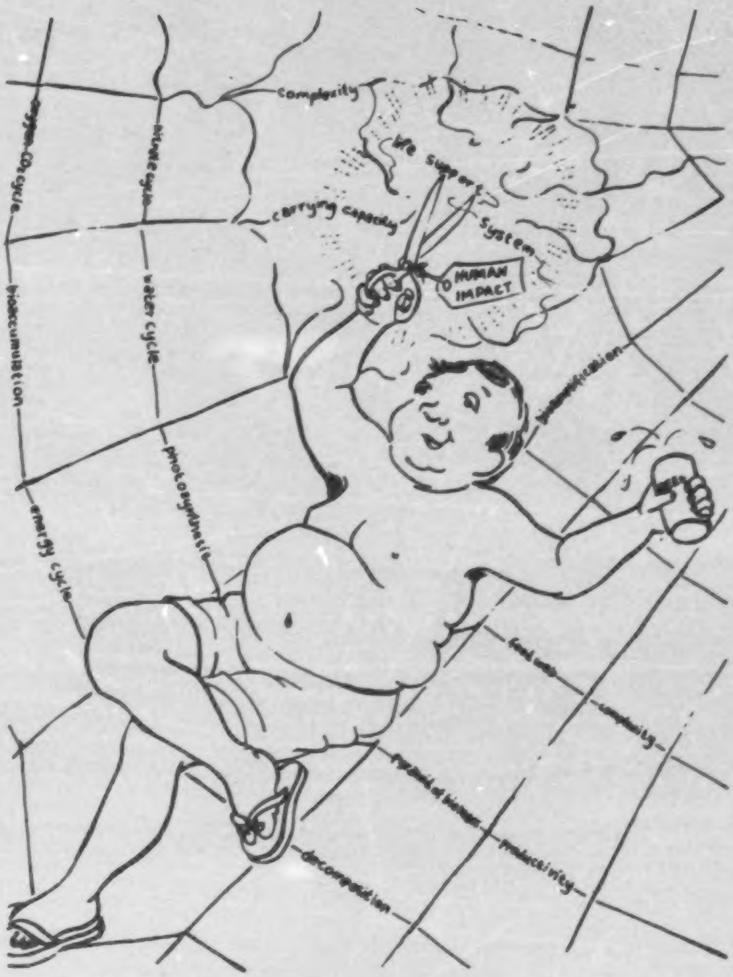
Consider the potato, a plant from South America. It was the major food of the Irish people in the 19th century. A blight nearly destroyed the 1845-46 crop. This caused widespread famine, death and emigration. The potato kept Germany alive during two World wars, and is still a staple to a great many people on Earth.

Agriculturists have worked and worked with the genetic potential of the Irish white potato. They have developed many good varieties.

Now consider the yam (not sweet potato but the true yam, Dioscorea, the nika and dagu of Guam). Yam began as a wild vine, probably in Africa. Today there are wild, half-wild and cultivated kinds. A few are on Guam and a lot in the rest of the World. Little scientific breeding of the yam has been done. It offers even greater genetic potential than the white potato. It will probably become more important as a major World food plant, provided we keep the wild and semi-wild varieties alive for the genetic bank.

The same holds true for other wild species. Most of our medicines were developed from plants, including the yam, source of a steroid used in treating arthritis. Plants and animals are great possibilities as sources for new medicines and other new products.

We have a long way to go before we fully understand this Island's ecology. Many inter-relationships exist that we don't yet know about. When we kill off species and interrupt natural cycles, the results may not at first seem serious; but remember, Nature bats last and always wins. Let's not cut the strands of the natural web that supports us.


complexity
oxygen-CO2 cycle
nitrate cycle
carrying capacity
life support system
HUMAN IMPACT
bioaccumulation
water cycle
photosynthesis
energy cycle
biomagnification
food web
complexity
pyramid of biomass
productivity
decomposition

We have yet other reasons to protect the wilderness. We have become so powerful that we can now destroy life on Earth, including our own. If we lose our contacts with Nature, we might do just that.

> "Hurt not the Earth, neither the sea, nor the trees."
>
> The Bible: Revelation 7:3

Activity 27 - An Investment In Your Future

Go for a walk or a swim in some wild place. Just enjoy it. It's a great thing to do. Sometimes, if the modern world is too hectic and the rat race gets you down, nothing will lift you up like a walk or swim in a wild place. If you appreciate wilderness, you will be able to turn to it in time of need.

Limits to Growth - Clearly the human population cannot continue to grow at its present rate. Limits to growth include amounts of:

space food other resources pollution

In the past, when people ran out of space, food or resources, or polluted a place until they could no longer live there, they moved elsewhere. Or they brought in outside resources. Now we are faced with running out of space and resources, and with polluting the whole World. Let's look at some of our limits.

Space - Some 1.5 billion hectares (abbreviation, ha) of land on Earth can be cultivated economically. The World's human population is now 4 billion. It takes about 0.6 ha per person to make a good diet, another 0.4 ha to produce the fibers we use, and another 0.2 ha per person for things like roads, airports, and buildings. That's 1.2 ha of land per person for an adequate life. Four billion people on 1.5 billion hectares is only 0.4 ha per person. We've already exceeded the limit three times over for a first-class life!

Food - In 1967 the President's Science Advisory Commission panel on World food supply reported that 1.5 to 2 billion people didn't get enough of the right foods.

An inadequate diet weakens people so they are more likely to get sick and die of other causes. Starvation may cause 20 million deaths each year.

Activity 28 - Diets

List everything you eat in any one day.
How does it compare with 'textbook' diets?
What would happen to your diet if there were no ships or planes bringing food to Guam?

Resources - Rapidly these are being used up. Hydrologists, water resource scientists, estimate that we take out more ground water than is being replaced by rain. Available reserves of certain metals such as zinc, tin, lead, and copper could be mined out in 20 years. Petroleum resources are also running out.

Activity 29 - Materials

What would your life on Guam be like if all your materials had to come only from Guam? What would you wear, live in, and what would you use to cook your food?

Pollution - Population growth causes pollution. Pollution is probably the most serious limiter to population growth. It lowers biological productivity. No matter how sophisticated we become we are still dependent on biological productivity of Earth's plant life for our sustenance.

The dimensions of pollution are difficult to measure. A lot of unseen and as yet unfelt effects occur. Most of us are being irritated by a little or a lot of pollution every day. We're a pretty big and strong species and seem able to protect ourselves from some effects of pollution. What about the smaller more vulnerable kinds of life that can't escape? It's only a matter of time before what affects them affects us.

Momentum and Overshooting the Limit

Have you ever run like mad to make second base and then not been able to stop? Have you been in a speeding car that had to stop fast? You know you can't just stop where you are if you're going pretty fast. You've got a lot of momentum to make you keep going.

With pollution, there may be a lag between the time we pollute the environment and the time the pollution effects start showing up. Sometimes pollution symptoms don't show up until it's too late. Some irreversible damage already has been done. Once a species becomes extinct, it's gone forever. Radioactive contamination of the environment may last a long long time. The people of Bikini in the Marshall Islands have been waiting for 30 years to return to their home which was contaminated by radioactivity from bomb tests.

The decrease in productivity triggered by biocides and other pollutants may make the difference in whether your great grandchildren's generation is well fed.

A person concerned with taking care of our World, Dr. Paul Ehrlich, compares our present situation to driving a car with poor brakes down a winding mountain road, faster and faster. The less effective our brakes become, the harder it is to stay on the road.

We don't know the carrying capacity of our Island, we don't know how close we are to the end of the road. It's like driving in the dark with the lights out, with some back seat drivers telling us there's no problem and we should keep our foot on the gas. Pretty soon, we'll run off the road or hit something. The longer we wait before slowing down the more likely we are to crash. Better to slow down now.

Exploiters, Spacemen, Islanders - Once, people in North America could stand on Earth looking out to the great horizon bounded by mountains, plains, or the limitless ocean. They could dream of all the new territory and riches which lay just beyond the horizon. They might believe that Earth was limitless, and seek to press ever onward using everything up as they discovered it. That was the age and idea of the exploiters: move ever westward to seek your fortune.

Today we have been to the Moon, and have looked back on our fortune, all of it——a small beautiful Earth.

Today we realize that our Earth is like a spaceship, traveling through the vast void, carrying with it all things needed for life by humans and a limited number of other life forms as our companions.

Exploiters could wreck one place and move on. Spacemen can't afford to damage their life-giving craft. They have to live a lot differently from fortune seekers. Look here:

The Exploiter	The Spaceman
move on, there's always more land and resources beyond the horizon	stay within the boundary of a finite Earth spaceship—— that's all there is
consume a lot of things	recycle, and be creative with what you have
have big families, fill up the vast land	limit your family to what will fit spaceship Earth
you can be a bad guy as long as you keep a move on and stay away.	you'll have to be responsible for your actions, there's no away to get to.

Islanders should make good spacemen. They've been living on little spaceships in the big ocean for a long time.

Back to Nature vs Technology

Some people would blame all our environment problems on technology. They talk about giving it up altogether and 'getting back to nature'. That's not enough to get us out of the jam we're in——technology helped us get here. We're going to need it to help us get out.

Developments in environmentally sound technology are some of the most exciting things happening today. The 'flower children' of yesterday have matured into the 'alternative technology' people of today, with lots of neat ideas and some devices for making better use of natural resources and cycles.

We have less-polluting alternatives, and we can use them. As we become aware of pollution's dangers, we'll become more willing to accept some temporary inconvenience for a healthier life and environment. Let's look at some alternatives.

Some Alternatives—Other Ways of Doing Things

On-Island Travel

You know that lovely stretch of trees and beach along East Agana Drive? It's soon to be bulldozed to make room for more cars. On Guam our life is shaped a lot by the car. It needs a lot of arrangements——roads, parking lots or buildings, gas stations, carports, garages. We are affected by traffic patterns, and we need to get from place to place in reasonable time. Cars are also a major source of air and junk pollution and environmental change.

We could reduce the number of cars by adopting mass transit ——buses——and car pools or bikes. Or else we could keep on widening roads and building more parking lots for more and more cars. Which alternative makes more sense?

Activity 30 - Count the Cars

Count how many people in cars go by in one direction. Stop when you get to 30 people. How many cars did it take? Would this many people fit into one bus? What fuel might the bus use? Would it produce more, or less pollution than the cars you counted?

Do you ride the bus or a car to school? Or do you ride a bike? If you ride a car, why? Is it a necessity, a convenience, or a luxury?

Sources of Energy

Most of our energy comes from burning fossil fuels. This uses up limited, non-renewable resources, and produces pollution. We have other sources of energy, and some of them can be used in our homes. You could design your own model, but for now it's probably better to build proven systems so other people can see them work——and maybe build one themselves. A great many books and reports on energy sources are available. Here's a short description of some possibilities.

Getting Electricity - In 1831 Michael Faraday and Joseph Henry discovered the electrical generator. When you turn a coil of wire in a magnetic field you generate electric current. Perhaps your science lab has a hand-cranked generator.

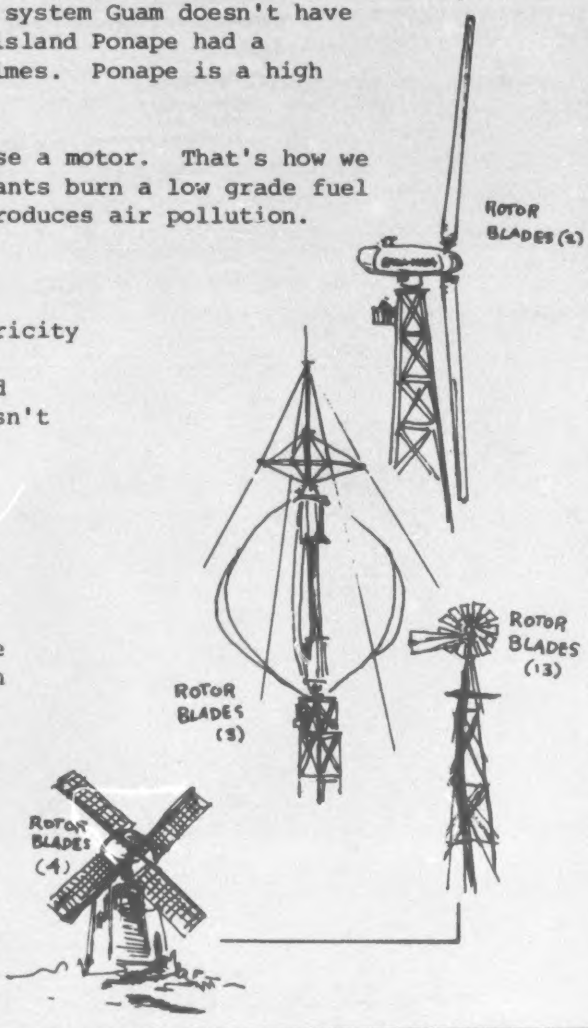
Electricity for stoves and lights in your home is made in the same way, but on a much grander scale, as in power plants.

One way to generate electricity is to use falling water. This is done in places which have big rivers. For a hydroelectric plant, a dam is put on the river and the water is funneled downhill to turn a turbine. For this system Guam doesn't have a big enough river, but our neighbor island Ponape had a hydroelectric plant during Japanese times. Ponape is a high island with a lot of rain and rivers.

Another way to turn a turbine is to use a motor. That's how we generate electricity on Guam. Our plants burn a low grade fuel which is high in sulfur content and produces air pollution.

Other ways to turn turbines:

Windmills - As the blades turn, electricity can be made in the same way as with a crank. This electricity can be stored in batteries to use when the wind doesn't blow. Windmills have been used for a long time to grind grain and to pump water. To make electricity they cost a lot in the beginning, mainly because of the batteries. They go on producing power for a long time using the wind, and that's free. For places having enough wind, they're a good deal. Guam's southern mountain ridge may be such a place. Some windmills are in use in the Trust Territory. The 2-kw model at Vocational-Technical High School, knocked down by Typhoon Pamela, is to be rebuilt on the rampart behind the school by mid-1977.



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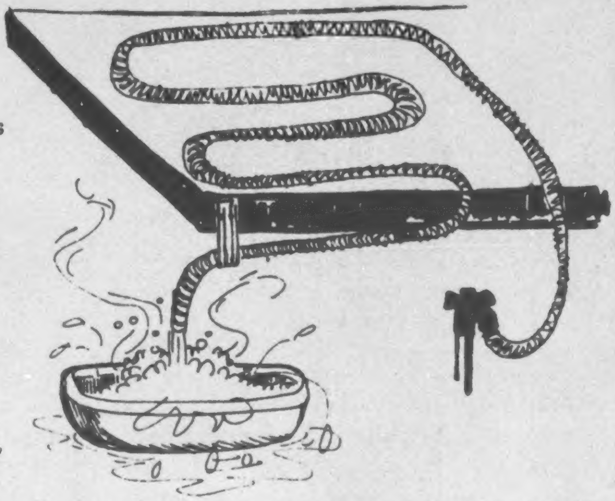
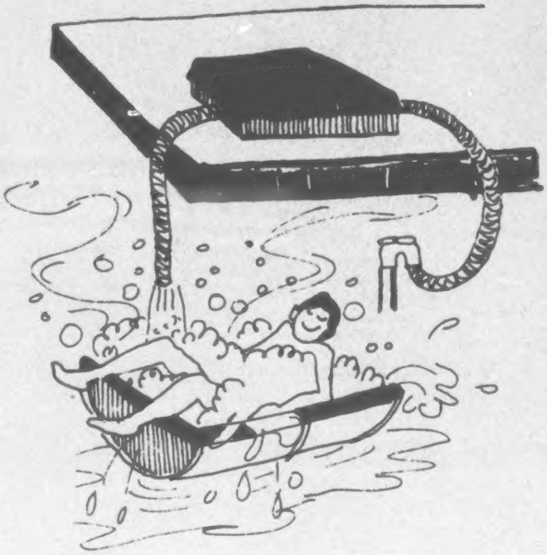
Solar Energy - Only a tiny bit of the Sun's energy reaching Earth is used. A lot more is available; it's free and non-polluting. Here are a few ways to use the Sun's power.

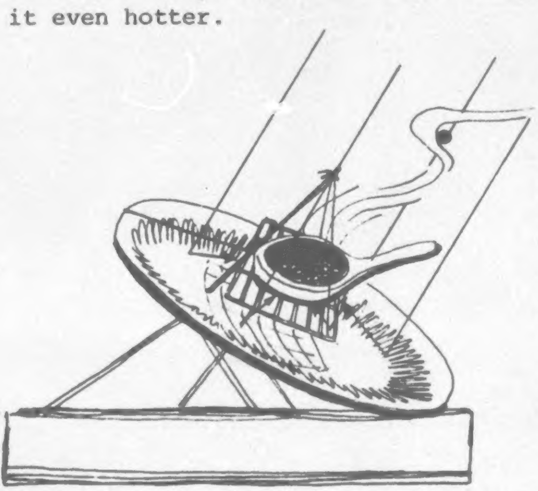


Put a water hose on your roof. The Sun will heat the water. Leave the end of the hose hanging down where you can reach it. Turn it off until you want it. If you paint it black, it will be even more effective. Why?



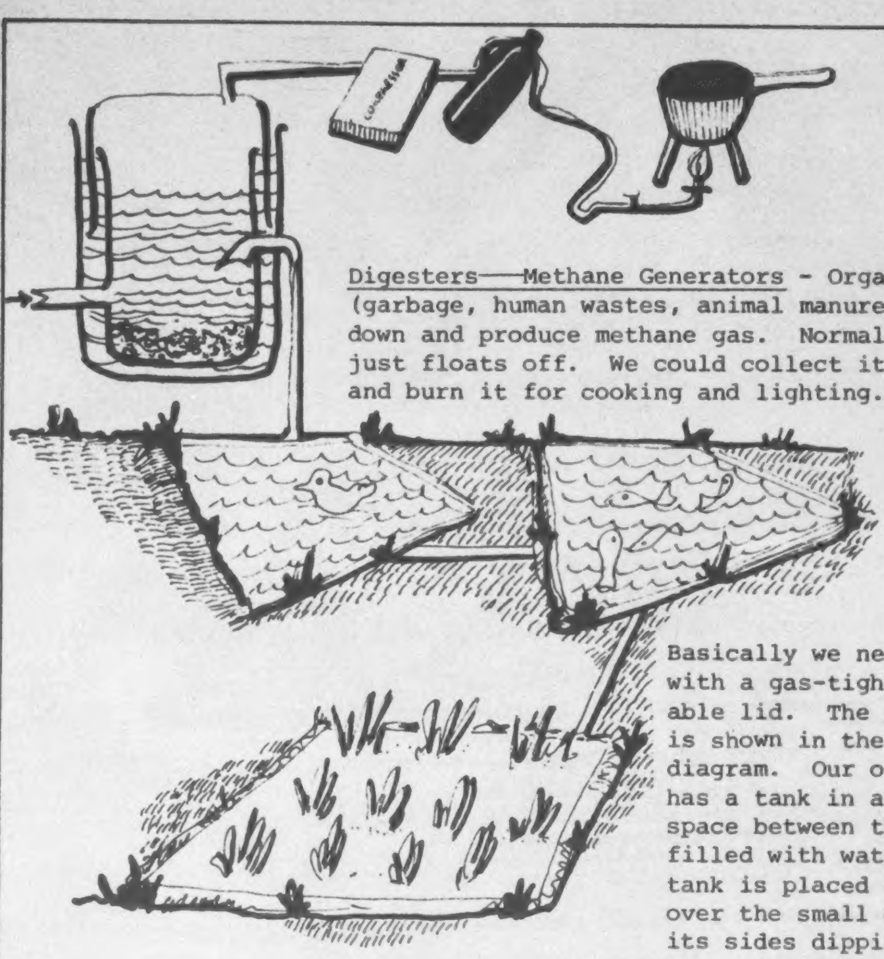
For a bigger solar water heater, put a tank on your roof. Paint it black to better absorb the Sun's heat. Put a piece of plastic over it to keep the heat in. Use a hose to fill and drain it. Use your solar water heater and you'll probably never need your electric one. (If you want to shut off your electric water heater, pull the electrical plug. A heater lacking a safety valve or having one that doesn't work could explode if you turn off the water valve and leave it plugged in.)

A solar heater can be a holding tank for an electric water heater. Some solar heaters use water rising in convection currents. They recirculate the already heated water and make it even hotter.

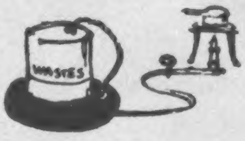


With a Fresnel lens or concave mirror you can focus the Sun's rays for cooking. Fireless barbecue stoves like this one are used many places and cook for free!

Solar energy also makes electricity directly, as in solar cells on spaceships. At present these are too expensive to use widely.



Digesters——Methane Generators - Organic wastes (garbage, human wastes, animal manure) break down and produce methane gas. Normally the gas just floats off. We could collect it, however, and burn it for cooking and lighting.



Basically we need a tank with a gas-tight, expandable lid. The principle is shown in the innertube diagram. Our other version has a tank in a tank. The space between them is filled with water. A third tank is placed upside down over the small one, with its sides dipping into the water.

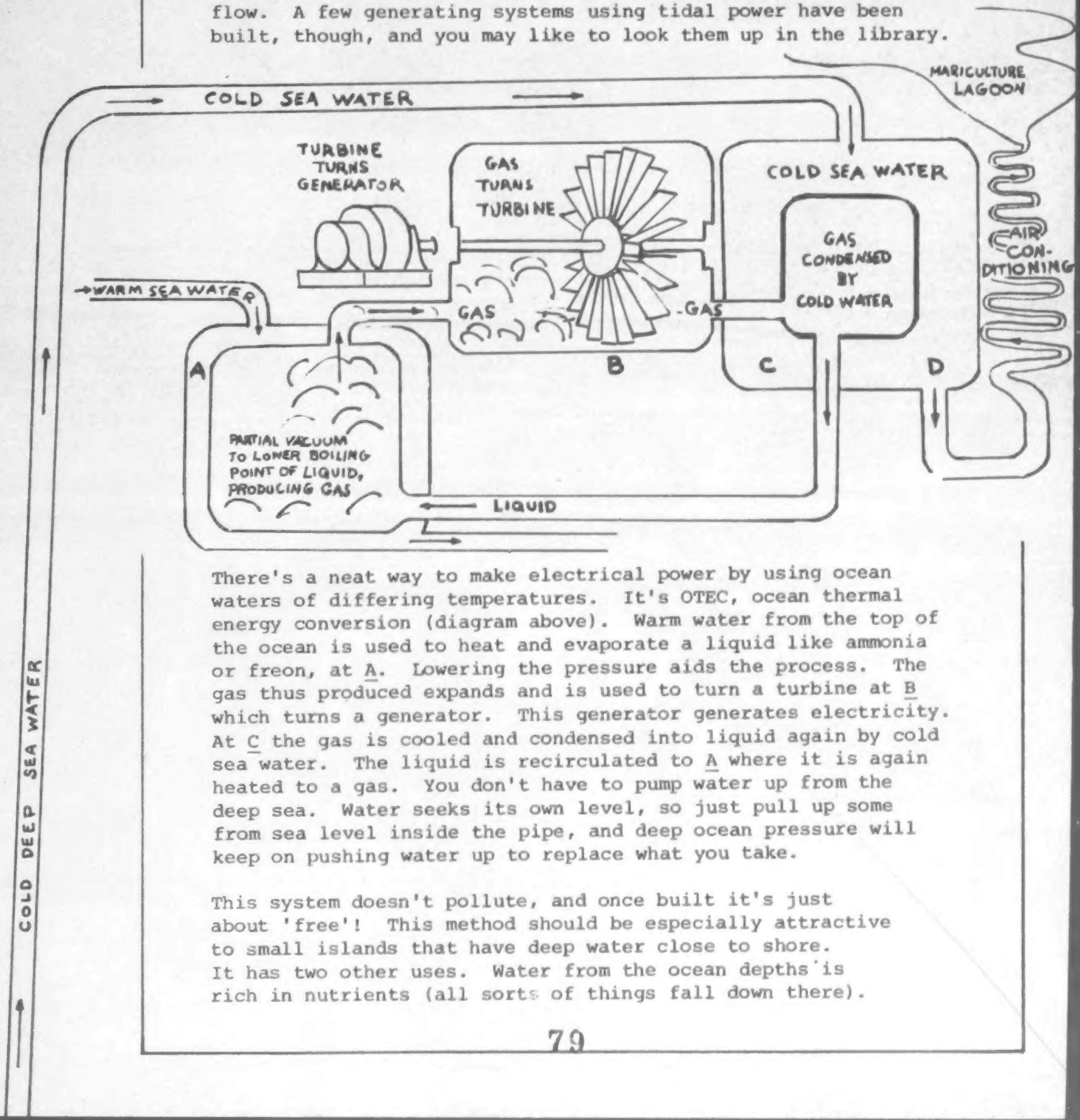
This makes a gas-tight seal so air can't get in and methane can't get out. The micro-organisms that produce methane gas are anaerobic——they work only in the absence of free oxygen.

Wastes come into the inside tank through the inlet pipe. There they decompose and make methane. The gas pushes up on the cover tank. Methane can be burned directly in a stove or gaslight. It can also be compressed and placed in a storage tank.

Most solid material put into the digester breaks down. The tank doesn't fill up with solids for a long time. The outlet pipe below water level carries liquid outflow containing a lot of nutrients. These can be used for fertilizer in a chain of aquaculture-agriculture plots. First the effluent goes into ponds which grow high protein algae for animal feed. Then it goes into a pond of fish and shrimp for people and domestic animals. After some time in the ponds the waste materials break down completely. Any harmful organisms that may have been present originally are dead. Water and debris from the last pond can be used to irrigate and fertilize crops.

The nutrient-rich water may then be used to irrigate vegetable gardens. This system is being used in parts of the World to provide 3 very important needs: fuel, fertilizer, and food.

Oceanwater Power - We've got a big ocean around us. How about using it for power? Currents made in channels when the tide changes can be used to turn turbines. However, this poses a number of problems. For one thing, the currents are powerful and it's hard to anchor the turbines. Also, currents shift over a long period, and there might not be enough permanent water flow. A few generating systems using tidal power have been built, though, and you may like to look them up in the library.


MARICULTURE LAGOON
COLD SEA WATER
TURBINE TURNS GENERATOR
GAS TURNS TURBINE
COLD SEA WATER
GAS CONDENSED BY COLD WATER
AIR CON-DITIONING
WARM SEA WATER
GAS
GAS
A
B
C
D
PARTIAL VACUUM TO LOWER BOILING POINT OF LIQUID, PRODUCING GAS
LIQUID
COLD DEEP SEA WATER

There's a neat way to make electrical power by using ocean waters of differing temperatures. It's OTEC, ocean thermal energy conversion (diagram above). Warm water from the top of the ocean is used to heat and evaporate a liquid like ammonia or freon, at A. Lowering the pressure aids the process. The gas thus produced expands and is used to turn a turbine at B which turns a generator. This generator generates electricity. At C the gas is cooled and condensed into liquid again by cold sea water. The liquid is recirculated to A where it is again heated to a gas. You don't have to pump water up from the deep sea. Water seeks its own level, so just pull up some from sea level inside the pipe, and deep ocean pressure will keep on pushing water up to replace what you take.

This system doesn't pollute, and once built it's just about 'free'! This method should be especially attractive to small islands that have deep water close to shore. It has two other uses. Water from the ocean depths is rich in nutrients (all sorts of things fall down there).

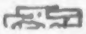
The water coming out of the power plant at D can therefore be used for mariculture, growing food in seawater. On its way to the mariculture site the cold water can be used to air-condition buildings. A few OTEC systems are already in use in other parts of the World. The main difficulty is in getting all the plumbing in. It's very expensive. You should hear more about this system in the near future. If not, ask about it!

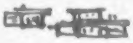
Nuclear Energy - A lot of energy holds the parts of an atom together. This energy can be released by breaking the atoms up (fission), or putting them together (fusion). This is the principle underlying nuclear power. The bombs over Hiroshima and Nagasaki showed the power stored in atomic bonds, but set free uncontrolled. For other uses, the problem is to control this power. Nuclear scientists are working on the problem and have already helped produce a number of nuclear power plants. A danger of nuclear accidents exists, however, and there are problems with waste heat. Most nuclear plants in operation today use fission. A fusion process also can be used and has many advantages. More fuel for it is available. Accidents are less likely. It produces less heat pollution. However, the fusion process is not yet well worked out. It may take 20 years or more to develop it into a practical energy source.

If we want to use nuclear energy and use the safer fusion process, we will have to conserve fuel now in order to buy time for its development.

Activity 31 - Conserving Energy

A. Who Gets the Energy - We face fuel and other energy shortages. In your notebook, list the uses of fuel oil on Guam. Put a checkmark by each one that has an effect on you.





After that, list the following in order of importance for having electrical power. Add others.

School
hospital
private home
retail store
government offices
bowling alley
movie house
hotel

Put the following in the order you think they ought to have fuel:

family cars
ambulances
airplanes
taxis
buses
farm equipment
racing cars
military equipment

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B. Using Electricity

1. List all the electrical things you and your family use at home.

2. Across from each write what you could do to cut down on the energy used by these electrical items.

3. Draw a line through the three you could most easily do without.

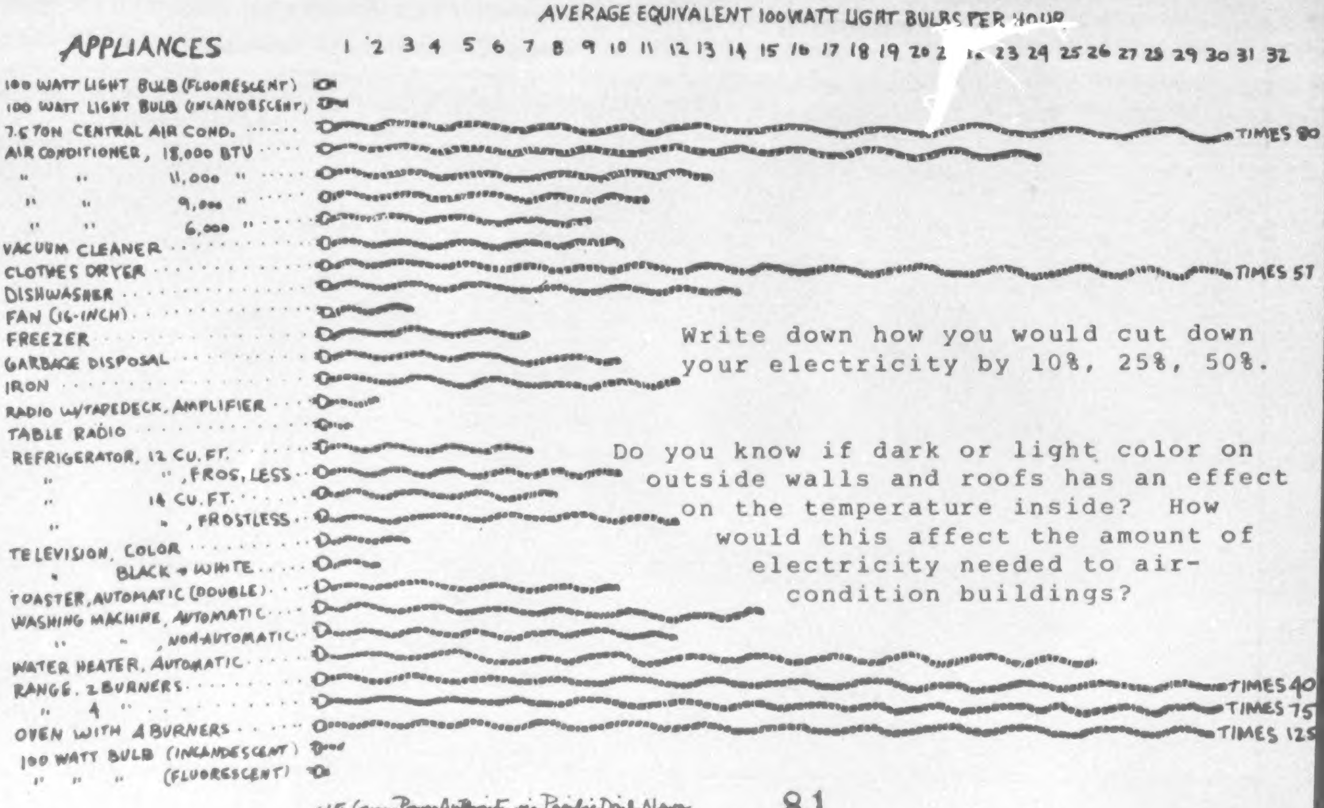
4. Draw a circle around the two you could least easily do without.

5. Turn off lights and appliances whenever they are not being used.

C. A High-Powered Decision - Would you be in favor of charging more for electricity when a home or business uses more, or would you rather reduce charges for each kilowatt hour as usage goes up? Do you support higher rates for more use, or lower rates for more use? What's the situation on Guam?

Activity 32 - Measuring Energy Use

Here's a table of energy use by light bulbs and appliances. List all the things using electricity at your home. Figure out how much energy they use all together. Check your total against your monthly reading of the electric meter on your house.



after Guam Power Authority via Pacific Daily News.

Write down how you would cut down your electricity by 10%, 25%, 50%.

Do you know if dark or light color on outside walls and roofs has an effect on the temperature inside? How would this affect the amount of electricity needed to air-condition buildings?

Other Alternatives

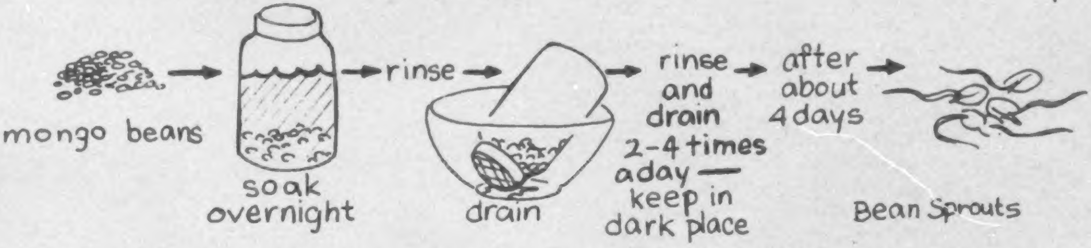
Eating Low on the Food Chain

It takes a lot more land and sea to support top carnivores than to support herbivores. It would help if we could live lower on the food chain—eat more plants, less meat.

Most plant foods aren't as high in proteins as animal foods are. We need proteins, or at least sets of amino acids to make them up. We could get enough of these amino acids in 3 ways: 1) eat lots of general plant foods to combine the small proportions of protein they contain, 2) eat a moderate amount of plant and animal foods with complete sets of amino acids, like milk, eggs, fish and meat, or 3) mix plant foods that have complementary amino acids. For example: beans are high in certain amino acids, but low in those found in rice. Beans and rice together give you a complete set. (Eating beans at one meal and rice at the next isn't 'mixing' them.)

Some combinations with the equivalent protein of a 5-6 oz. steak: 1/2 cup beans or peas with 1 1/3 C rice; 1/6 C soybeans with 1 1/2 C rice; 1/2 C peanuts with 3/4 C sunflower seeds; 2 C cornmeal with 1/2 C beans. Read more about the fun idea of complementary amino acids in Diet for a Small Planet by Frances Lappé.

Another trick is to eat sprouts. They are high in nutrients, and cost very little if you grow them yourself. To sprout your own, soak untreated seeds—mongo beans, lentils, alfalfa, corn, etc.—overnight in plain water. Then rinse them 2-4 times a day. (If you forget once in a while, that's okay.) Keep them in a dark place. In a few days you'll have sprouts for salad, Chinese cooking or other dishes.



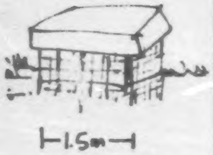
Organic Gardening

Organic Gardening - raising plants without chemical fertilizers and biocides. It makes ecological sense. With it, you can develop soil rich in the stuff that makes it nutritious for plants. You can do it by composting.

There are many ways to make your compost pile. Here are some: Dig a pit or make a fence enclosure. Or put a ring around a banana tree. Or put it right in the garden where you're going to use it—an especially good method here where it rains a lot and nutrients are washed out of the soil fast.

COMPOST TABLE

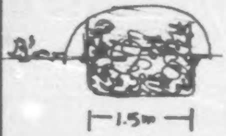
Plant materials	Animal materials for nitrogen	Other Things
cut grass	manure (of all kinds, pigs, cows, rabbits, etc.)	kitchen garbage
leaves	hair	coffee grounds and tea leaves.
sawdust (from untreated lumber)	sewage sludge	old cloth
seaweed	etc.	lime or sand
vines		dirt
coconut husks		etc.
weeds		



For fast compost, chop or shred these things into small pieces.

Pile in layers about 15 cm thick:

- dirt, other things
- plant material
- animal material
- dirt, other things
- plant stuff
- animal stuff



Add other things anywhere. To speed up decomposition, add more animal stuff. If it smells, it's working! If it's really too smelly add a little lime (calcium oxide, CaO).

Keep the pile moist but not soaking. Don't let the pit fill with water. If possible, cover with black plastic. This will keep moisture in, add heat, help prevent scavenging, and keep the weeds from sprouting again. Look on page 12... See anything that should be added to help out? (Remember earthworms!) If all goes well, the pile will heat up from the work of all those decomposers, and the organic wastes will become beautiful rich soil in a few weeks. The time varies depending on things like how fine the materials were, and how much animal waste there was. Use this supersoil in your garden!

Much household waste can be recycled into rich soil. Choose a method that suits you and grow yourself an organic garden. Consult Farm and Garden in the LOG series and Organic Gardening magazine.

Mixed Planting - In agriculture we should use the biological ideal of complexity.

Nowadays, big farms often raise just one crop. This is monoculture. It runs the risk of having an organism that feeds on the crop come along and wipe out the whole operation. People can't afford this. They usually counterattack with pesticides which will supposedly kill off the pests. Pesticides do take a toll but they increase the resistance of the pests that survive. Pesticides also reduce natural complexity and make a system even more dependent on biocides. They are hard on natural systems.

A way to get around the monoculture problem is to have mixed plantings. Then pest species have a harder time building up to wipe out one crop.

Some farmers put insect-repelling plants like onions or garlic next to plants that are bothered a lot by insects. Some Philippine tribes purposely grow wild shrubs such as ahgao (Premna obtusifolia) to serve as 'insect absorbers' attracting the bugs away from their crops. (See page 23 Limestone Forest, LOG Series.)

Many old-time Guam farmers practice mixed planting. Because of its great practicality, mixed planting will someday become a 'modern' planting technique, especially in the Tropics. If you look at an old-time Guam garden, you might not recognize it as a garden. There are scattered fruit trees and wild trees and patches of suni (taro) and bananas, and here and there dagu and nika (yam) vines climbing up into the trees, and pumpkins creeping over the trash pile. The area might not be all cleared off and lined up but it is very productive, and that's what counts.

The Puka Shell and Other Beauties

We've had some highly destructive fads. People bought a lot of sealskin coats, tigerskin rugs and turtleshell jewelry. Those fads put too much hunting pressure on the animals which produced the hides and shells. They're all endangered species now.

It isn't wrong to appreciate seal fur, tiger skin, and turtleshell; each carries with it the feeling of that one place where it was created: an isolated rocky shore, an Asian jungle, a beautiful lagoon. But the numbers are limited——if everybody had one they would disappear.

Nature abounds in beauties that express the essence of their special place. One example is puka shells. When the tiny mollusks that make puka shells die, the remains are cast up on our white beaches and bleached by the Sun. They were just small bits of shell strewn about the beach. Then the social value of a new fad centered on them, and people started collecting and wearing them. So far it's a fad that does no harm.

Activity 33 - Alternative Beauty

Look around, find something naturally beautiful that is not alive or directly important to anything that is alive. Wear it to school. To the class, point out its beauty and other characteristics, like color, pattern, how it was formed by natural forces, and so on.

Alternatives and Decisions

Today almost everyone is 'for' ecology. However, few people understand what is really involved in environmental problems.

It is easy to pass right by what's really wrong. Some people do things in the name of the environment that have little or nothing to do with maintaining and improving it. Did you ever see a tree trunk painted white at the bottom? Look at the picture on page 35. Probably this was done by a group that wanted to improve Guam's environment. Does painting tree bottoms do any good? What it shows is that some people care. That's important. Still, it's too bad to lose the valuable energy of people who want to help but don't know what to do. This is where you come in. You know some important things about caring for the environment. Now you can help others know.

Next time you're faced with a problem, try this approach: 1) Define it. 2) Think up as many alternative solutions as possible. 3) Consider their consequences. 4) Decide on the best alternative. 5) Act on your decision!

On the next pages are some environmental situations. See how you would go about solving them. Put your notes and responses in your notebook.

Activity 34 - Children or Free Wild Places

You own 4 hectares of land and have always left 2 of them wild because you love to go exploring in free wild places. You marry and have 2 children whom you take along with you when you wander there. Soon they too come to love wandering in free wild places.

Most families around you have many children and your relatives keep asking when you're going to have more. You know that if you have more, you will have to cut down the wild forest you all love, because you will need to raise more food to support the larger family.

What would you: 1) decide? 2) tell your relatives?

Activity 35 - Taxing For and Against a Growing Population

In today's income tax structure, families pay less tax if they have more children. This favors people with large families. Would you prefer this method, or a taxing system in which people with more children pay more taxes? Why, or why not?

Activity 36 - A Matter of Priorities I: First Things First

You are the director of Health Services for an island whose main food is taro grown by the women. Sometimes the women get infections from working in the taro patch. Which of the following would you do?

1. Forbid your wife to work in the taro patch. Get your taro from relatives or buy it with your big salary.

2. Forbid everyone to work in the taro patch. Ask for money from the United States to buy rice for your people.

3. Try to discover the cause of the infection and how to combat it.

Activity 37 - A Matter of Priorities II

Which of the following projects do you feel has the most long-term value?

1. Creating a new 'wonder drug'.

2. Determining a way to take nitrogen oxides from the air.

3. Developing a non-polluting automobile.

Give reasons for your choice.

Activity 38 - Fresh Fish or Canned?

Your home is a small island. Much of your fish supply is caught by stretching a net across the mouth of the small channel leading into the lagoon. The trapped fish are easy to catch.

A government official comes and suggests that the channel be blasted to make it bigger so a ship can come in. Then you will be able to sell copra to the ship and use the money to buy things from it.

You know you won't be able to catch fish in the old way if the channel is widened. You really like canned fish but you don't like the work that goes into making copra to sell. Also, the ship wouldn't visit your island very often because it can't make much money from your small copra harvest.

Discuss the alternatives.

Activity 39 - Money vs Oily Turtles

You are administrator of the local Environmental Protection Agency. A large foreign ship goes aground on an uninhabited island in your district. The ship's tanks still hold a lot of diesel and lubricating oil. You request that the oil be pumped onto other ships before it leaks and spills on the beach.

The local ecologist reports that the uninhabited island is an important rookery, a nesting ground for sea turtles which are a source of food for people on neighboring islands. Sea turtles return to the beach where they hatched to lay eggs. Nobody knows just how they find their way back. The ecologist is afraid that an oil spill from the ship could interfere with the turtles' ability to recognize their own nesting beach.

The Coast Guard is responsible for preventing oil spills, and has money to do this and to clean up any spills. The fund is kept up with fines collected from those responsible for oil spill risks.

The Coast Guard tells you as EPA administrator that it will cost a lot to pump out the ship. Since the ship is foreign, it may not be possible to collect a fine to cover the cost of pumping. The Coast Guard asks you to reconsider your request to have the oil pumped out.

What would you do?

Activity 40 - Aerial Spraying

This plane sprayed Tumon Bay with pesticide in 1975. It was done after a few cases of dengue fever were diagnosed among Vietnamese refugees on Guam. (Many more cases were suspected by Public Health.) Dengue fever is carried by mosquitoes that bite infected people. The spraying was to kill the mosquitoes so they would not spread the disease from sick people to well people. Besides killing mosquitoes, the spray killed bees and other beneficial insects and fish. Look up dengue fever and its effects. Make two lists. In one put good effects of the spraying. In the second put the bad effects. How do you feel about the spraying?

Activity 41 - Basic Rights

Here is Dr. Paul Ehrlich's list of people's eleven basic rights. Consider each one. Do you agree with all of them? Would you add any or subtract any? Discuss them with your friends.

The right to eat well.
The right to drink clean water.

The right to breathe clean air.
The right to decent, uncrowded shelter.

The right to enjoy natural beauty.
The right to avoid regimentation.

The right to avoid pesticide poisoning.
The right to freedom from thermonuclear war.

The right to limit families.
The right to educate our children.
The right to have grandchildren.

Activity 42 - Shuffling the Environmental Deck

This is a stack of cards with neat quotations. Look through them. Do one or both of the things below.

1. Choose the one you like best. Write it in your notebook. Explain to the class what it means to you.

2. Using the Contents and the Activities and Cross Reference lists, sort the cards by subject. Choose one subject and talk about it. For your talk use the cards, this book, and anything else you wish.

Activity 43 - Other Ways

Some people are turning to alternate life styles, other ways of living. These are pretty experimental and varied. In general, though, they turn away from conspicuous consumption, using up a lot to show off, and move toward self-sufficient living. You can read about it in Mother Earth News, The Whole Earth Catalog, Small Stock Journal, Rain, Organic Gardening, and other 'now' publications.

Look through some alternate life style magazines. Make an outline of the subjects covered in one issue of one of them. Discuss the relationship of one of these subjects to some basics of ecology.

Activity 44 - Workshop

PART I: Your class is a consulting firm: The owners of Island X sold it and moved to San Diego, drawn by the bright city lights. Some young people bought the Island. They want to live there ecologically soundly and self-sufficiently. They've hired you. Your job: plan the community.

Start from scratch. Follow the Rules of Thumb. In your notebook write a plan with Man and Nature in harmony.

PART II (In Teams): Now you've practiced on make-believe, Island X. It's time to tackle a toughie: You are a consultant for Guam. You're given the task of making life on Guam more ecologically sound. What would you do?

Make sure you cover all aspects of the job——ecological, technical, and political. Choose one particular goal and stick to it. It might be to make a plan for households to be more self-sufficient; to plan a small farm using a digester; to produce a family planning or population control program; or to create any other program you might choose.

Now, be reasonable. With Island X, you had a blank slate and could do anything you wished. This time you're dealing with a populated island. Remember the limitations of Guam's society. Don't propose something that would make your parents throw you out of the house. Instead, make a plan that will minimize their objections and maximize their support and demonstrate your own conscientiousness, to show that you really care. It's a real challenge, isn't it?

Activity 45 - Express Yourself

Make an environmental statement in public or to a government agency. In your notebook write the statement, and where and how it was made.

Activity 47 - Your 'Now' Environmental Coat of Arms

Do Activity 1 making an environmental Coat of Arms for how you feel now. Put your 'Now' Coat of Arms on the back cover of your notebook.

Activity 46 - An Ecologically Valid Life Style For You

The only way to make the World the way it should be is to start living that way. Start now. Make yourself a plan. Begin with the way you live now and describe the steps you will take to make your life as ecologically sound as possible. Don't propose something you can't carry out. Do stretch yourself to your limit, though. Start carrying out your plan.

Good luck, the World is up to you!

Cross Reference List

Main Topics: Aspects and Pages:

AIR—— cycles 5, 7, 8, pollution 43, monitoring on Guam 55.

BIOCIDES——37, bioamplification 14, biological warfare 21, alternatives 38, sprayed or damaged fruit 40, heavy metals 41, hazardous wastes 50, aerial spraying 80.

CYCLES vs ONE-WAY PHENOMENA——life depends on recycling 5, some of the main cycles: water 5, carbon-oxygen 7, nitrogen 9, energy 9; an ecological ideal 17, effects of biocides on water cycle 38, DDT not easily biodegradable 38, radiation 42, 66, 73, oil not very biodegradable 46, fresh fish or canned 79.

ECOSYSTEMS—— 3, organisms 3, species 3, biosphere 3, 17, complexity 13, 63, rules of thumb 17, pollution 35.

ENERGY——in order to release food energy we need oxygen 7, the energy cycle 9, we get all our energy from the Sun through photosynthesis 9-10, alternate sources 69-73.

FOOD——produced by photosynthesis 7, nitrogen needed for proteins 9, energy cycle 9, starvation 17, 65, eating low on food chain 75, sprouts 75, organic gardening 75, fresh fish or canned 79.

HUMAN IMPACT——Earth time chart 4, unnatural selection 21, pollution 35, 54, 66, environmental impact 55 ff., interference with cycles 64, resources depletion 65.

LIFE STYLE——technology 21, 68-73, unnatural selection 21, money 22, hard times 28, environment and life style 29-33, wants re-examined 34, nature appreciation 34, alternatives to pesticides 38, support for GEPA 55, exploiters, spacemen, islanders 67, cars 68, energy 69-75, organic gardening 75, fads 77, workshop 82, an ecologically valid life style 82.

POPULATION——22-28, biomass 13-14, children or free wild places 78, taxing population growth 78.

PRODUCTIVITY AND CARRYING CAPACITY——16, 66, biomass 13-14, territoriality 14, 15, overpopulation 27, effects of silt 35, effects of DDT 38.

RESOURCES——fossil fuels 4, freshwater reserves 5, 6, 45, territoriality 14, 15, land 23, 65, hard times 28, solid wastes 48, environmental impact statements 56, zoning 62, nature reserves 62, genetic bank 63, limits 65, exploiters, spacemen, islanders 67, children or free wild places 78.

SPECIES DIVERSITY AND ENDANGERED SPECIES——species definition 3, complexity 13, 63, natural selection 15-16, effects of biocides 37-38, biological controls 39-40, mixed planting 39, 76-77, our vanishing companion life 57-62, turtles 60, 80, genetic bank 63.

WATER——cycle 5, need by plants and animals 6, freshwater reserves 5, 6, 45, contamination with DDT 37-38, pollution 45-48, monitoring pollution levels 55.

Acknowledgements

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Photos, other than the author's: page 36 - Piti Bay, Gary Stillberger; 39 - young praying mantises, Jeff Shafer; 80 - spray plane/Tumon Bay, Simona C. Villoria; 57 - megapode chick, probably the first of this species ever published, Frankie Cushing---my thanks are due my brother also for pointing out lots about Guam's natural history that isn't found in books.

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